FRIENDSHIP LAKE
LAKE CLASSIFICATION REPORT

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EXECUTIVE SUMMARY

Background Information about Friendship Lake

Friendship Lake is located in Adams County in south central Wisconsin and is a 115-acre impoundment (man-made) lake located in the Towns of Adams and Preston, Adams County, in the Central Sand Plains Area of Wisconsin. This lake is formed by an impoundment of Little Roche a Cri Creek. Little Roche a Cri Creek ultimately empties into the Wisconsin River. The Little Roche a Cri Creek watershed is large, covering 196.20 square miles and extending into the next county east of Adams. Friendship Lake has two public boat ramps, one connected to a public park and beach; the other a rough ramp near a bridge. There are several Native American archeological and American historical sites located in the Friendship Lake watersheds that cannot be further disturbed without permission of the federal government an/or input from the local tribes.

The soils in both the surface and ground watersheds for Friendship Lake are mainly loamy sand, muck and sand, with slopes from very flat up to 45%. Water, air and nutrients move through these soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Wind erosion, water erosion and drought are common hazards of these soil types. The muck soils tend to pond and are generally not subject to erosion unless the soils are exposed and dried out.

Land Use in Friendship Lake Watersheds

Both the surface and ground watersheds of Friendship Lake are fairly large. In the surface and ground watersheds, the two most common current land uses are woodlands and irrigated agriculture. Both watersheds have large areas of wetlands. Wetlands also play several important roles in maintaining water quality, in the aquatic food chain and in wildlife nesting. It is essential to preserve these wetlands for the health of Friendship Lake.

Friendship Lake has a total shoreline of 5.9 miles (31,152 feet). Much of the lakeshore is in residential use. Many of the areas near the shore are steeply sloped, except in the far northwest end, where the land is flatter and where the beach and large boat launch are located.

A 2004 shoreline survey showed that about 75% of Friendship Lake's shore is vegetated. The rest of the shore is a mix of sand, rock and/or other hard structure. Several areas also have significant erosion occurring, especially on the very steep, sandy banks.

The 2004 inventory also classified shorelines has having "adequate" or "inadequate" buffers. An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. 20.77% of the shore on Friendship Lake had inadequate buffers.

Most of the "inadequate" buffer areas were found with small beaches, mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line. Adequate buffers on Friendship Lake could be easily installed on most of the lake by either letting the first 35 feet landward from the water just grow without mowing it, or by planting native seedlings sufficient to fill in the first 35 feet.

<u>Water Testing Results</u>

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on Friendship Lake. Overall, Friendship Lake was determined to be a mesotrophic lake with fair to good water quality and good water clarity.

Measuring the phosphorus in a lake system provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2006 summer average phosphorus concentration in Friendship Lake was 36 micrograms/liter. This average is over the 30 micrograms/liter level recommended to avoid nuisance algal blooms. This concentration suggests that Friendship Lake is likely to have nuisance algal blooms.

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Friendship Lake in 2004-2006 was 6.52 feet. This is good water clarity.

Chlorophyll-a concentration provides a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. The 2004-2006 summer (June-September) average chlorophyll-a concentration in Friendship Lake was 11.5 micrograms/liter, a fairly low algal concentration for an impoundment. Chlorophyll-a averages have stayed low in Friendship Lake since 1995, the first year for which records were found, when the average was 6.5 micrograms/liter.

Friendship Lake water testing results showed “hard” water with an average of 129.9 mg/l $CaCO_3$. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

A lake with a neutral or slightly alkaline pH like Friendship Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake’s fish cannot reproduce. That is not a problem at Friendship Lake, since its surface water alkalinity averages 98.4 milliequivalents/liter. The pH levels from the bottom of the lake to the surface hovered between nearly 7 and 8, alkaline enough to buffer acid rain.

Most of the other water quality testing at Friendship Lake showed no areas of concern. The average calcium level in Friendship Lake’s water during the testing period was 28.98 mg/l. The average Magnesium level was 13.58 mg/l. Both of these are low-level readings. Both sodium and potassium levels in Friendship Lake are very low: the average sodium level was 1.83 mg/l; the average potassium reading was .98 mg/l. To prevent the formation of hydrogen sulfate gas, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Sulfate levels in Friendship Lake are 16.43 mg/l, above the level for formation of hydrogen sulfate, but below the health advisory level. Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Very turbid waters may not only smell and mask bacteria & other pollutants, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Friendship Lake were at low levels between 2004-2006.

Some water testing results indicated a need to continue monitoring the nutrients to make sure no problems are developing. The presence of a significant amount of chloride over a period of time may indicate that there are negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. Chloride levels found in Friendship Lake during the testing period averaged 4.43 mg/l, considerably over the natural level of 3 mg/l for this region of Wisconsin.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Friendship Lake's combination spring levels from 2004 to 2006 average 1.83 mg/l, far above the .3 mg/l predictive level. This could be a problem because the growth level of Eurasian watermilfoil, the main invasive aquatic plant species in Friendship Lake, has been correlated with fertilization of lake sediments by nitrogen-rich runoff.

<u>Phosphorus</u>

Like most lakes in Wisconsin, Friendship Lake is a phosphorus-limited lake: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other water quality aspects.

The total phosphorus (TP) concentration in a lake is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a man-made lake like Friendship Lake, a total phosphorus concentration below 30 micrograms/liter tends to result in few nuisance algal blooms. Friendship Lake's growing season (June-September) surface average total phosphorus level of 35 micrograms/liter is over that limit, suggesting that phosphorus-related nuisance algal blooms may occur.

Land use plays a major role in phosphorus loading. The land uses around Friendship Lake that contribute the most phosphorus are irrigated and non-irrigated agriculture. Some phosphorus deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration along waterways; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Such practices need to be implemented in all of the Little Roche a Cri Creek Watershed in order for a significant impact on phosphorus reduction to occur.

Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% would improve Friendship Lake in-lake water quality by reducing the total phosphorus levels 2 to 10 micrograms/liter; a 25% reduction would reduce the in-lake phosphorus by 6 to 19 micrograms/liter. Reductions of 25% could put the lake low enough in total phosphorus levels that algal blooms would be greatly reduced. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Friendship Lake's health for future generations.

Aquatic Plant Community

The aquatic plant community of Friendship Lake is characterized by below average quality and good species diversity. The plant community survey suggests that Friendship Lake is in the group of lakes in Wisconsin and the North Central Hardwoods Region that are most tolerant of disturbance.

The Friendship Lake aquatic plant community has colonized 88.9% of the littoral zone and most of the lake overall. The 0-1.5 feet depth zone supported the most frequent and most abundant aquatic plant growth. The dominant species in Friendship Lake was *Vallisneria americana* (water celery). Sub-dominant were *Wolffia Columbiana* (common watermeal), *Ceratophyllum demersum* (coontail) and *Lemna minor* (small duckweed).

Three invasive species—*Myriophyllum spicatum* (European watermilfoil), *Phalaris arundinacea* (Reed canarygrass) and *Potamogeton crispus* (Curly-leaf pondweed)—were found in the 2006 aquatic plant survey. The one occurring most frequently and densely is Eurasian watermilfoil. For the past several years, the Friendship Lake District has been using mechanical harvesting and removal of the harvesting results to manage the aquatic invasives in the lake. It also has management of aquatic plant species and aquatic invasives incorporated into its lake management plan.

Critical Habitat Areas

Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes. Three areas on Friendship Lake were determined by a team of lake professionals to be appropriate for critical habitat designation.

Three areas on Friendship Lake were determined to be appropriate for critical habitat designation. FR1 extends along approximately 6000 feet of the eastern shoreline (both sides) of Friendship Lake, up to the ordinary high water mark. FR2 extends along approximately 5000 feet of the north and south shoreline in the middle of the lake's length. FR3 covers 2100 of the southwestern lake shore.

Fish/Wildlife/Endangered Resources

WDNR fish stocking records for Friendship Lake go back to 1933, when walleye and black bass were stocked. Through the next 25 years, stocking occurred frequently, generally concentrating on largemouth & smallmouth bass, bluegills, perch, walleye and northern pike. There was a fish removal in 1984 that revealed that there were about four times more bluegills than all the other fish found put together. The most recent inventory, done in 2002, found that largemouth bass and bluegills were abundant, yellow perch and white sucker were scarce, and pumpkinseed and black crappie were present. Carp have also been found in the lake in the past.

Many kinds of wildlife are known to use the Friendship Lake shores for cover, reproduction and feeding. These include muskrat, mink, various waterfowl, songbirds, turkey, frogs, salamanders, turtles and snakes, as well as some upland wildlife.

Many endangered resources are found in the Friendship Lake watersheds. Natural communities known to be present include alder thicket, central poor fen, floodplain forest, northern dry forest, northern sedge meadow, oak barrens, pine barrens, sand barrens, shrub-carr and stream (fast, hard, cold). Endangered birds found are Greater Prairie Chicken and Red-Shouldered Hawk. Invertebrates of concern include Karner Blue Butterfly, Persius Dusky Wing Butterfly, and Sand Snaketail dragonfly. Several endangered plants—Crossleaf Milkwort, Slim-Stem Small Reedgrass, Whip Nutrush—are also present.

Conclusion

Friendship Lake is currently a small impoundment impacted substantially by its large surface and ground watersheds. The Friendship Lake District will need to regularly review and update its lake management plan in order to address the management issues in a logical, cohesive manner. The recommendations on the following pages and the information in this report will help in these aims.

RECOMMENDATIONS

Lake Management Plan

The Friendship Lake District needs to regularly review and update its lake management plan in order to address the management issues. The plan needs to always address the following: aquatic plant management; control/management of invasive species; wildlife and fishery management; watershed management; shoreland protection; critical habitat protection; water quality protection; inventory & management of the larger watershed.

Watershed Recommendations

Results of the modeling certainly suggest that input of nutrients from the watersheds, especially phosphorus, are factors that need to be explored for Friendship Lake.

Therefore, it is recommended that both the surface and ground watersheds be inventoried, documenting any of the following: runoff from any livestock operations that may be entering the surface water; soil erosion sites; agricultural producers not complying with nutrient management plans and/or irrigation water management plans. If such sites are documented, steps for dealing with these issues can be incorporated into the lake management plan as needed.

The Friendship Lake District should consider approaching the WDNR or conservancy organizations to explore putting the east end of the lake, with its meandering stream and wetlands, into a conservancy or limited development area to assure that those areas won't be changed in a way that would degrade water quality of the lake.

Shoreland Recommendations

All lake residents should practice best management on their lake properties, including keeping septic systems cleaned and in proper condition, eliminating the use of lawn fertilizers, cleaning up pet wastes and not composting near the water.

Aquatic Plants/Aquatic Invasives Recommendations

1) Residents should continue involvement in the Citizen Lake Water Monitoring, Invasive Species Monitoring and Clean Boats, Clean Waters Programs. This will allow not only noting changes in the Eurasian Watermilfoil and other invasives patterns, but also discover any new invasions. Noting the presence and density of such species early is the best way to take preventive action to keep them from becoming bigger problems.

2) Lake residents should protect and restore natural shoreline around Friendship Lake. Studies have shown that there is lower frequency and density of the most sensitive plant species in disturbed shoreline areas. Disturbed shoreline sites support an aquatic plant community that is generally less able to resist invasions of exotic species and show impacts from nutrient enrichment.

3) In particular, the current areas of heavy erosion need to be addressed by installation of shoreland protection and stormwater management practices.

4) All lake users should protect the aquatic plant community in Friendship Lake by disturbing plant beds as little as possible, by stormwater management to reduce runoff, and by installation of shoreland protection to reduce deposit of eroded material into the lake's waters.

5) The Friendship Lake District should maintain exotic species signs at the boat landings and contact DNR if the signs are missing or damaged.

6) The Friendship Lake District should continue monitoring and control of Eurasian Watermilfoil and the other invasives, using the most effective methods, with modification if necessary. Early-season treatments with a specific chemical might be considered to know back the plant, followed by a regular harvesting schedule and pattern. Residents should be encouraged to hand-pull scattered EWM plants.

Critical Habitat Recommendations

There are also several recommendations appropriate for the critical habitat areas:

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove any fallen trees along the shoreline.
(3) No alteration of littoral zone unless to improve spawning habitat.

(4) Seasonal protection of spawning habitat.
(5) Maintain any snag/cavity trees for nesting.
(6) Install nest boxes.
(7) Maintain or increase wildlife corridor.
(8) Maintain no-wake lake designation.
(9) Protect emergent vegetation.
(10) Seasonal control of Eurasian Watermilfoil and other invasives with methods selective for control of exotics.
(11) Minimize aquatic plant and shore plant removal to maximum 30' wide viewing/access corridor and navigation purposes. Leave as much vegetation as possible to protect water quality and habitat.
(12) Use best management practices.
(13) No use of lawn products.
(14) No bank grading or grading of adjacent land.
(15) No pier placement, boat landings, development or other shoreline disturbance in the shore area of the wetland corridor.
(16) No pier construction or other activity except by permit using a case-by-case evaluation and only using light-penetrating materials.
(17) No installation of pea gravel or sand blankets.
(18) No bank restoration unless the erosion index scores moderate or high.
(19) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(20) Placement of swimming rafts or other recreational floating devices only by permit.
(21) Maintain aquatic vegetation buffer in undisturbed condition for wildlife habitat, fish use and water quality protection.
(22) Post exotic species information at public boat landing.
(23) Investigate making the far east end of the lake a conservancy or purchasing an easement to maintain its mostly undisturbed state.

LAKE CLASSIFICATION REPORT FOR FRIENDSHIP LAKE, ADAMS COUNTY

INTRODUCTION

In 2003, The Adams County Land & Water Conservation Department (Adams County LWCD) determined that a significant amount of natural resource data needed to be collected on the lakes with public access in order to provide it and the public with information necessary to manage the lakes in a manner that would preserve or improve water quality and keep it appropriate for public use. In some instances, there was significant historical data about a particular lake; in that instance, the study activities concentrated on combining and updating information. In other instances, there was no information on a lake, so study activities concentrating on gathering data about that lake. Further, it was discovered that information was scattered among various citizens, so often what information was actually available regarding a particular lake was unknown. To assist in updating some information and gathering baseline information, plus centralize the data collected, so the public may access it. The Adams County LWCD received a series of grants from the Wisconsin Department of Natural Resources (WDNR) from the Lake Classification Grant Program.

Objectives of the study were:

- collect physical data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- collect chemical and biological data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- develop a library of lake information that is centrally located and accessible to the public and to City, County, State and Federal agencies.
- make specific recommendations for actions and strategies for the protection, preservation and management of the lakes and their watersheds.
- create a baseline for future lake water quality monitoring.
- Provide technical information for the development of comprehensive lake management plans for each lake
- provide a basis for the water quality component of the Adams County Land and Water Resource Management Plan. Components of the plan will be incorporated into Adams County's "Smart Growth Plan".
- develop and implement educational programs and materials to inform and education lake area property owners and lake users in Adams County.

METHODS OF DATA COLLECTION

To collect the physical data, the following methods were used:

- delineation & mapping of ground & surface watersheds using topographic maps, ground truthing and computer modeling;
- identification of flow patterns for both the surface & ground watersheds using known flow maps and topographic maps;
- inventory & mapping of current land use with orthographic photos and collected county information;
- inventory & mapping of shoreline erosion and buffers using county parcel maps and visual observation;
- inventory & mapping for historical and cultural sites using information from the local historical society and the Wisconsin Historical Society;
- identification & mapping of critical habitat areas with WDNR and Adams County LWCD staff;
- identification & mapping of endangered or threatened natural resources (including natural communities, plant & animal species) using information from the Natural Heritage Inventory of Wisconsin;
- identification & mapping of wetland areas using WDNR and Natural Resource Conservation Service wetland maps;
- preparation of soil maps for each of the lake watersheds using soil survey data from the Natural Resource Conservation Service.

To collect water quality information, different methods were used:

- for three years, lakes were sampled during late winter, at spring and fall turnover, and several times during the summer for various parameters of water quality, including dissolved oxygen, relevant to fish survival and total phosphorus, related to aquatic plant and algae growth;
- random samples from wells in each lake watershed were taken in two years and tested for several factors;
- aquatic plant surveys were done on all 20 lakes and reports prepared, including identification of exotics, identifying existing aquatic plant community, evaluation of community measures, mapping of plant distribution, and recommendations;
- all lakes were evaluated for critical habitat areas, with reports and recommendations being made to the respective lakes and the WDNR;
- lake water quality modeling was done using data collected, as well as historical data where it was available.

WATER QUALITY COMPUTER MODELING

Wisconsin developed a computer modeling program called WiLMS (Wisconsin Lake Modeling Suite) to assist in determining the amount of phosphorus being loaded annually into a lake, as well as the probable source of that phosphorus. This suite has many models, including Lake Total Phosphorus Prediction, Lake Eutrophic Analysis Procedure, Expanded Trophic Response, Summary Trophic Response, Internal Load Estimator, Prediction & Uncertainty Analysis, and Water & Nutrient Outflow. The models that various types of data inputs: known water chemistry; surface area of lake; mean depth of lake; volume of lake; land use types & acreage. This information is then used in the various models to determine the hydrologic budget, estimated residence time, flushing rate, and other parameters.

Using the data collected over the course of the studies, various models were run under the WiLMS Suite. These water quality models are computer-based mathematical models that simulate lake water quality and watershed runoff conditions. They are meant to be a tool to assist in predicting changes in water quality when watershed management activities are simulated. For example, a model might estimate how much water quality improvement would occur if watershed sources of phosphorus inputs were reduced. However, it should be understood that these models predict only a <u>relative</u> response, not an exact response. Modeling results will be incorporated into topic discussions as appropriate.

DISSEMINATION OF PROJECT DELIVERABLES

The results of this study will be distributed various agencies, organizations and the public as previously described. Based on the classification information, the Adams County Land and Water Conservation Department will identify assistance requests and determine the appropriate future activities, based on the classification determinations. To provide the requested assistance, Adams County Land and Water Conservation Department will incorporate the lake management plans goals, priorities and action items into its Annual Plan of Operations. Goals, priorities and action items may include educational programs, formation of lake districts, further development of lake management plans and implementation of lake management plans.

ADAMS COUNTY INFORMATION

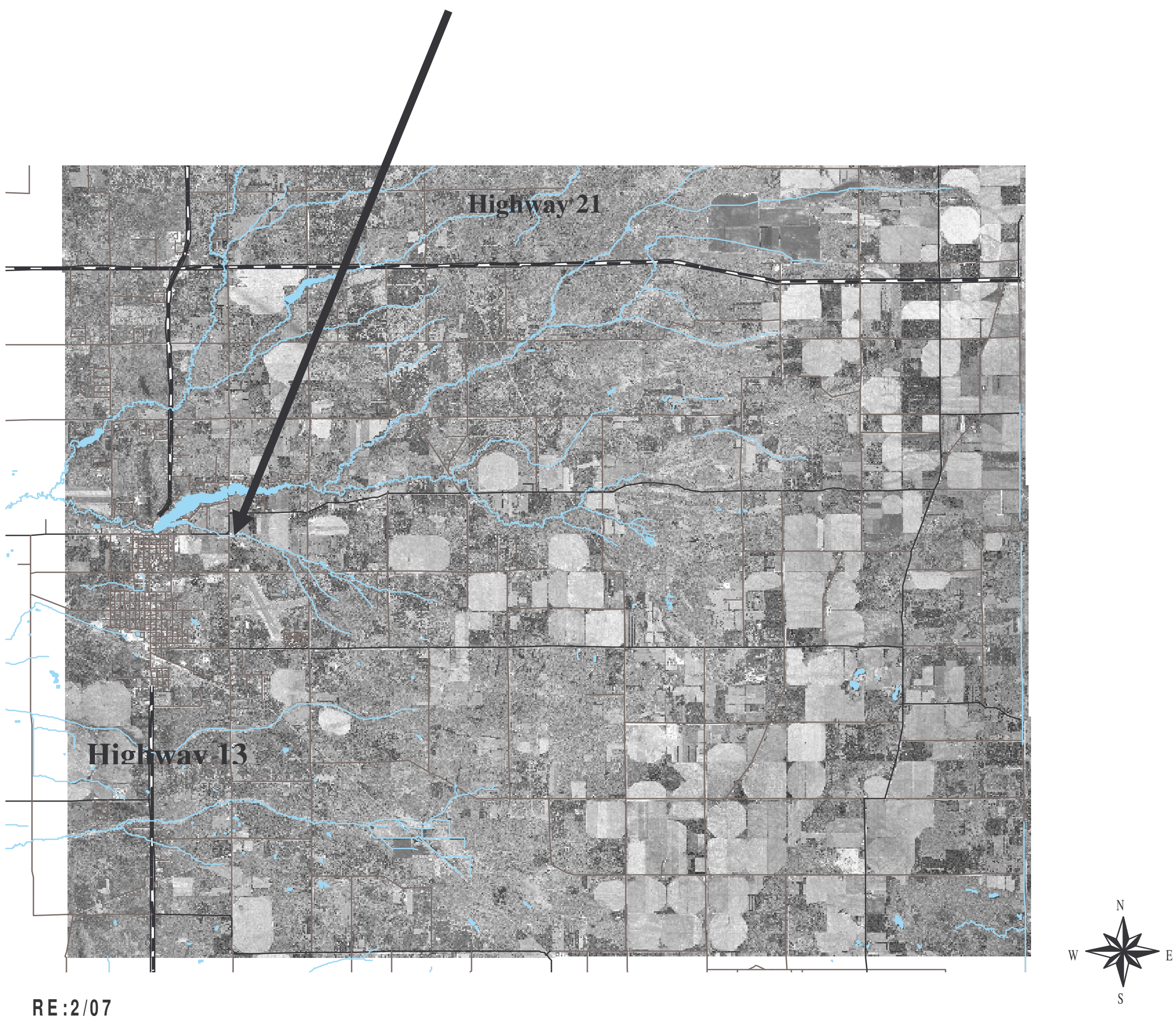
Adams County lies in south central Wisconsin, shaped roughly like the outline of Illinois. Adams County is a small rural county with a full-time population of about 20,000. Between 1980 and 2000, Adams County's population grew by more than 20%, with most of the population increase being located upon the lakes and streams. The population increase has resulted in a greater need for facilitation, technical assistance and education, including information on the lakes and streams.

Figure 1: Adams County Location in Wisconsin

FRIENDSHIP LAKE BACKGROUND INFORMATION

Friendship Lake is a 115-acre impoundment (man-made lake) located in the Towns of Adams and Preston, Adams County, in the Central Sand Plains Area of Wisconsin. As an impoundment of Little Roche a Cri Creek, it has both an inlet and outlet. Through Friendship Lake moves input of a very large watershed that extends into the next county east.

Figure 2: FRIENDSHIP LAKE location

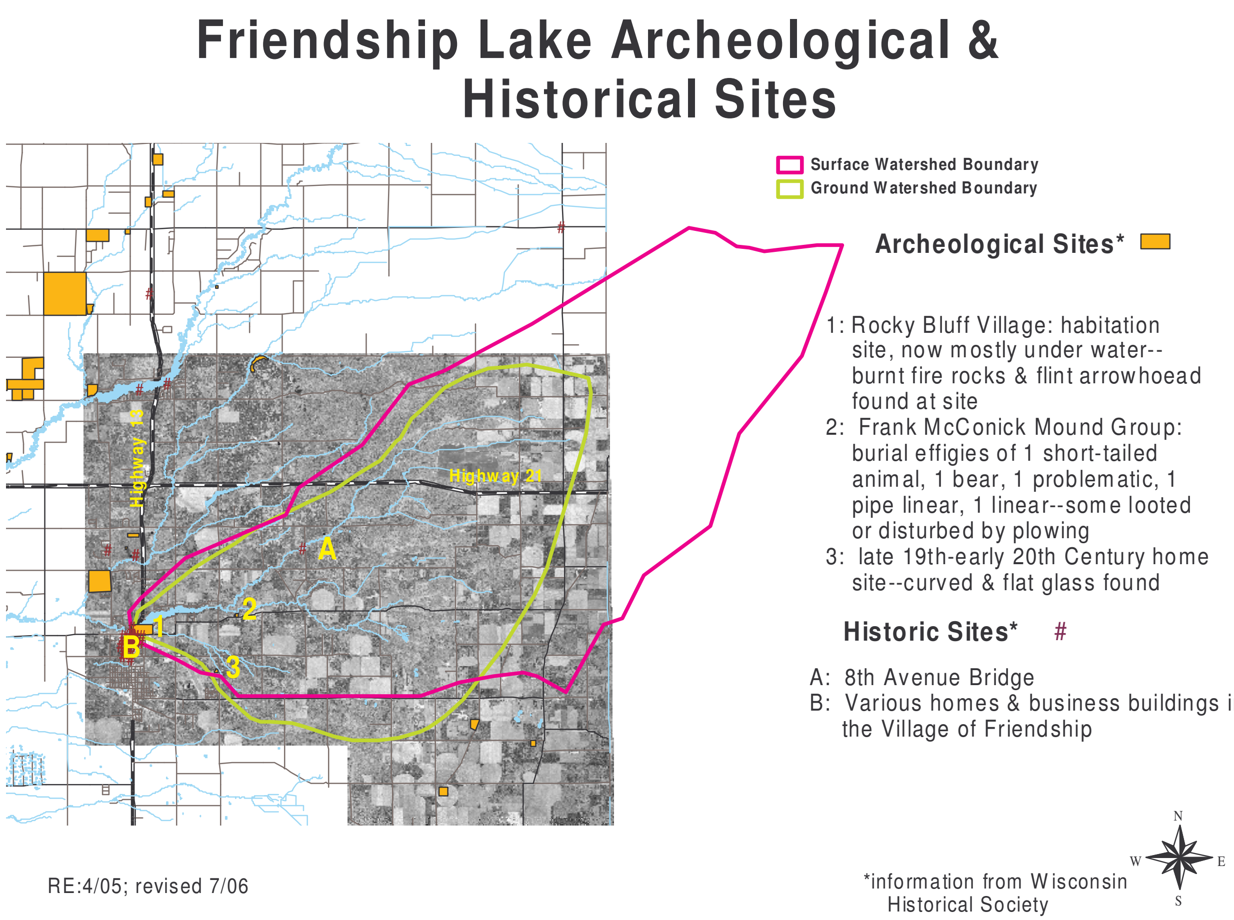


Friendship Lake is part of the Little Roche a Cri Creek, a large watershed of 196.20 square miles (125,567.04 acres) from which water flows eventually into the Wisconsin River. The Central Sand Plains, which contain Friendship Lake, are found in the Driftless Area of Wisconsin. The area is characterized by varying elevations, with numerous, usually flat-topped ridges & hills sometimes called "mounds." Deposits made by streams from the melting ice sheet cover large areas and usually consist of sand, clay and gravel.

Archeological Sites

There are many Native American archeological and American historical sites in Adams County, with some located in the Friendship Lake watersheds. Under the federal act on Native American burials, the burial sites cannot be further disturbed without permission of the federal government and input from the local tribes.

Figure 3: Friendship Lake Archeological Sites



Bedrock and Historical Vegetation

Bedrock around Friendship Lake is mostly sandstone, both weak and resistant, formed in the Cambrian Period of Geology (542 to 488 millions years ago). Bedrock may be 200 or more feet below the sand/clay/gravel deposits left by melting ice cover.

Original upland vegetation of the area included extensive wetlands of many types (including open bogs, shrub swamps & sedge meadows), as well as prairies, oak forests, savannahs and barrens. Mesic white pine & hemlock forests were found in the northwest portion of the region. Most of the historic wetlands were drained in the 1900s and used for cropping. The current forested areas are mostly oak-dominated, followed by aspen and pines. There are also small portions of maple-basswood forest and lowland hardwoods.

Soils in the Friendship Lake Watersheds

The soils in the Friendship Lake surface watershed are roughly 1/3 sand, 1/3 loamy and, and 1/3 muck. The same soil types cover the ground watershed, although in slightly different proportions.

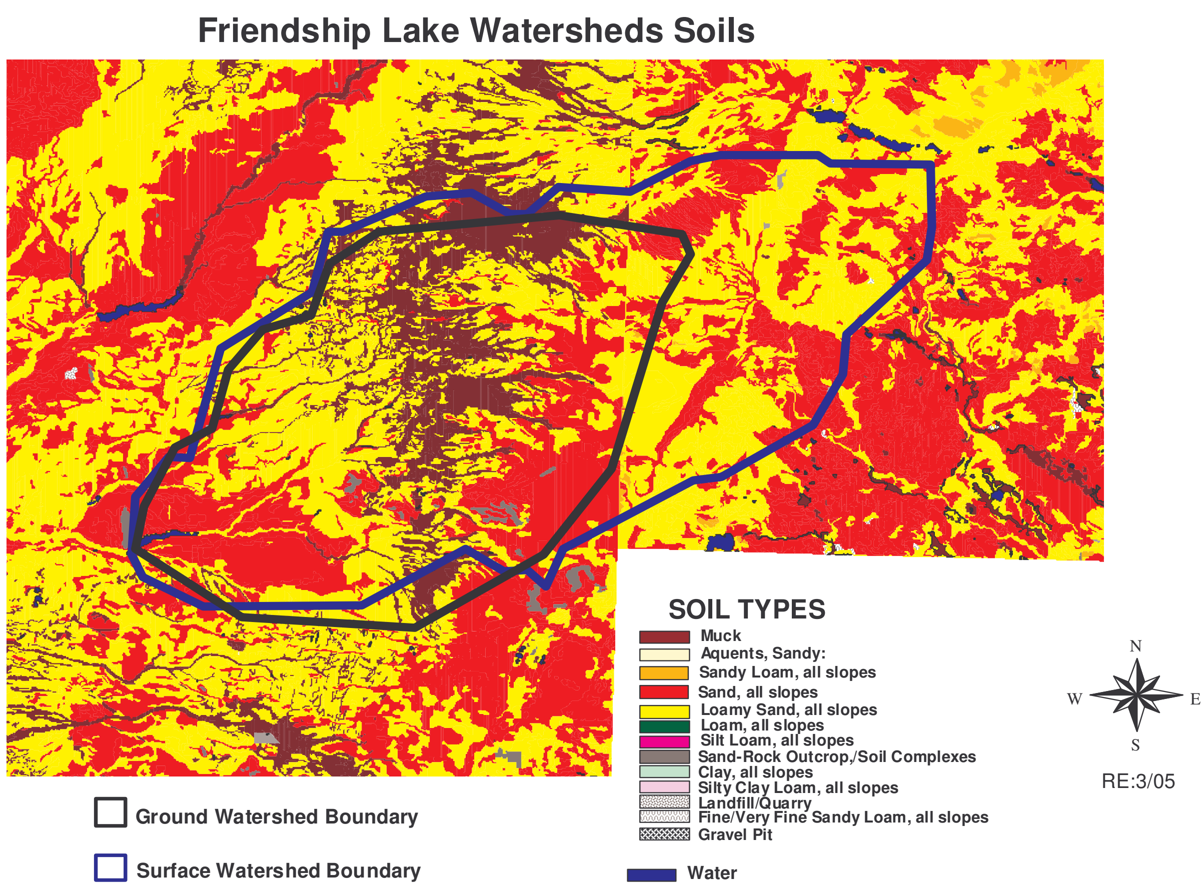
Sandy soil tends to be excessively drained, no matter what the slope. Water, air and nutrients move through sandy soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Although water erosion can be a problem, wind erosion may be more of a hazard with sandy soils, especially since these soils dry out so quickly. There are also draught hazards with sandy soils. Getting vegetation started in sandy soils is often difficult due to the low available water capacity, as well as low natural fertility and organic material. Onsite waste disposal in sandy soils is also a problem because of slope and seepage; mound systems are usually required.

Loamy sands tend to be well-drained, with water, air and nutrients moving through them at a rapid rate. Runoff, when it occurs, tends to be slow. Loamy sands have little water-holding capacity and low natural fertility, although they usually have more organic matter present than do sandy soils. Both wind and water erosion are potential hazards with loamy sands, as is draught. The same difficulties with waste disposal and vegetation establishment are present with loamy sands as with sandy soils.

Muck soils tend to be poorly to very poorly drained. They usually have significant organic matter, but low natural fertility. Available water capacity is very high. Roots of most crops are restricted by the seasonal high water tables, often without a foot of the surface in undrained areas. Water and air move through the surface layer of the soil fairly rapidly, but slowly in the lower soil depths. Runoff will pond. These soils are not suited for building site development or onsite waste disposal, due to the high water table and flooding hazard. If drained, the soils can be farmed, but will have soil blowing hazard and possible burning hazard if the organic material dries out.

The soil and soil slopes around lakes and streams are very important to water quality. They affect amount of infiltration of surface precipitation into the ground and the amount of contaminants that may reach the groundwater, as well as the amount of surface stormwater runoff. In addition, these two factors affect the amount and content of pollutants and particles (including soil) that may wash into a water body, affecting its water quality, its aquatic plant community and its fishery. Further, soil types and soil slopes help determine the appropriate private sewage system and other engineering practices for a particular site, since they affect absorption, filtration and infiltration of contamination from engineering practices.

Figure 4: Soils in the Watersheds



CURRENT LAND USE

Both the surface and ground watersheds for Friendship Lake are fairly large. Friendship Lake also receives significant input of materials from the large upper watershed. In the surface watershed, the main two land use types are Woodlands and Irrigated Agriculture. The same two land uses are the largest land use types in the ground watershed. (See Figures 5, 6a, 6b & 7).

Figure 5: Friendship Lake Watersheds Land Use in Acres and Percent of Total

	Surface		Ground		Total	
Friendship Lake						
Agriculture--Non Irrigated	1894.16	11.37%	758.03	11.41%	2652.19	11.38%
Agriculture--Irrigated	7237.08	43.43%	1929.28	29.04%	9166.36	39.33%
Government	24.97	0.15%	10.63	0.16%	35.6	0.15%
Grassland/Pasture	188.08	1.13%	39.86	0.60%	227.94	0.98%
Residential	1033.63	6.20%	635.12	9.56%	1668.75	7.16%
Water	311.25	1.87%	251.13	3.78%	562.38	2.41%
Woodland	5975.43	35.85%	3019.47	45.45%	8994.9	38.59%
total	16,664.60	100.00%	6643.52	100.00%	23308.12	100.00%

Studies have shown that land use around a lake has a great impact on the water quality of that lake, especially in the amount and content of surface runoff. (James, T., 1992, I-10; Kibler, D.F., ed. 1982. 271) For example, while natural woodland may (on the average) absorb 3.5” out of a 4” rainfall, leaving only .5” as runoff, a residential area with quarter-acre lots may absorb only 2.3” of the 4”, leaving 1.7” to run off the land into the lake—the same amount as may be expected to run off from a corn or soybean field. 1.7” of runoff translates into 46,200 gallons per acre ending up in the lake! Percentage of impervious surface, the soil type, vegetation present and slope of the site can all affect runoff volume. (Frankenberger, J, ID-230).

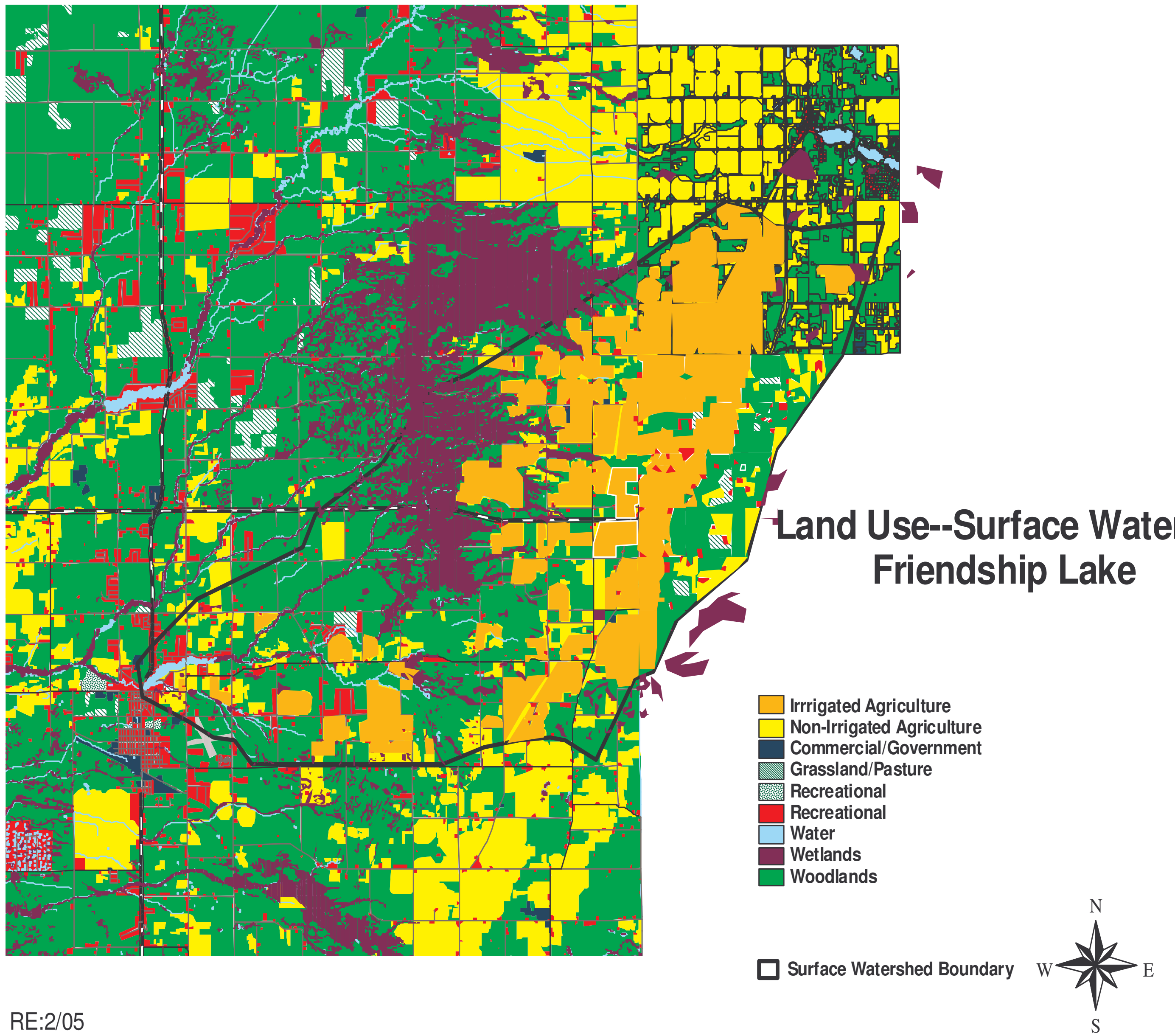
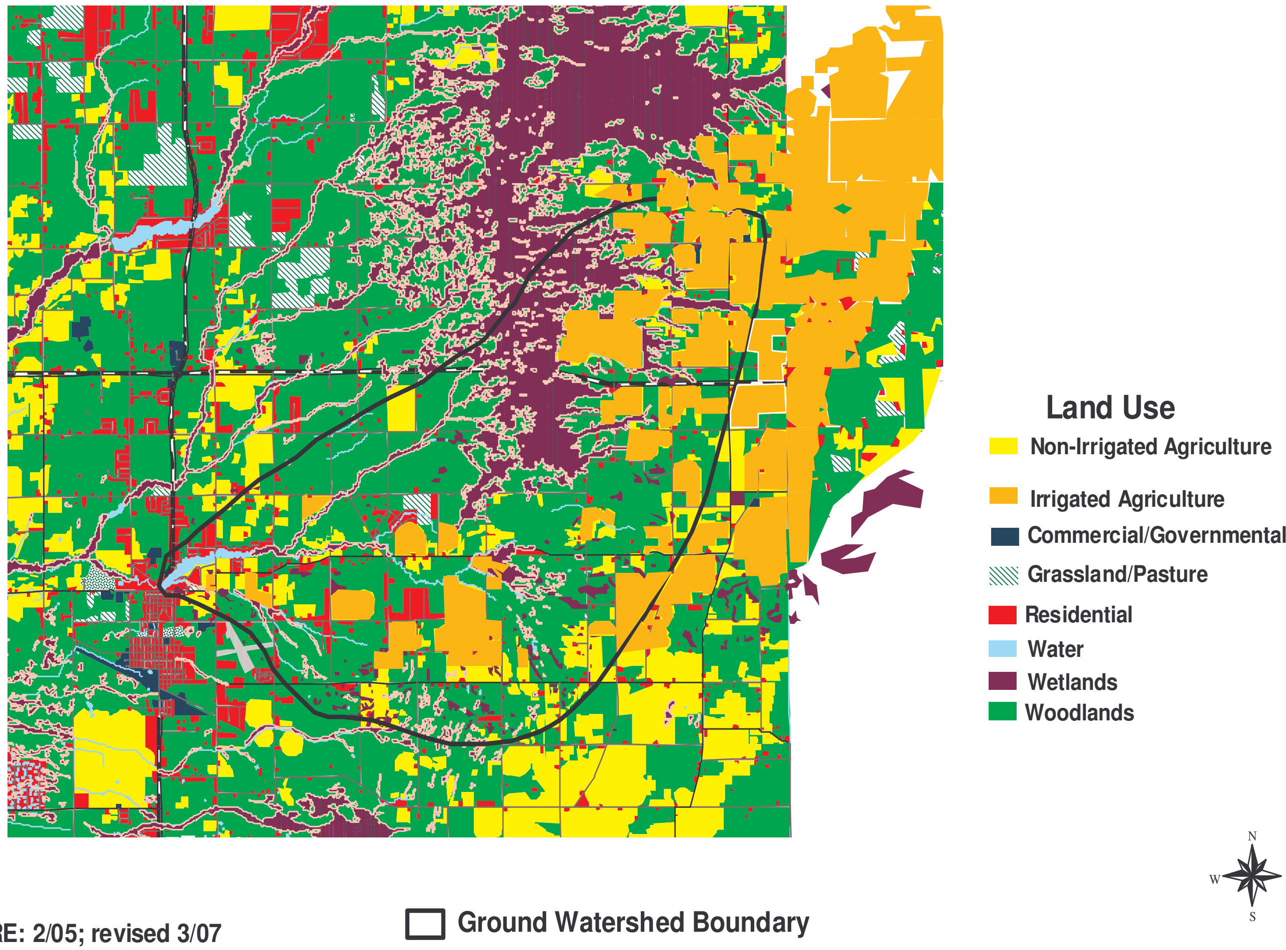


Figure 6a: Land Use in Friendship Lake Surface Watershed

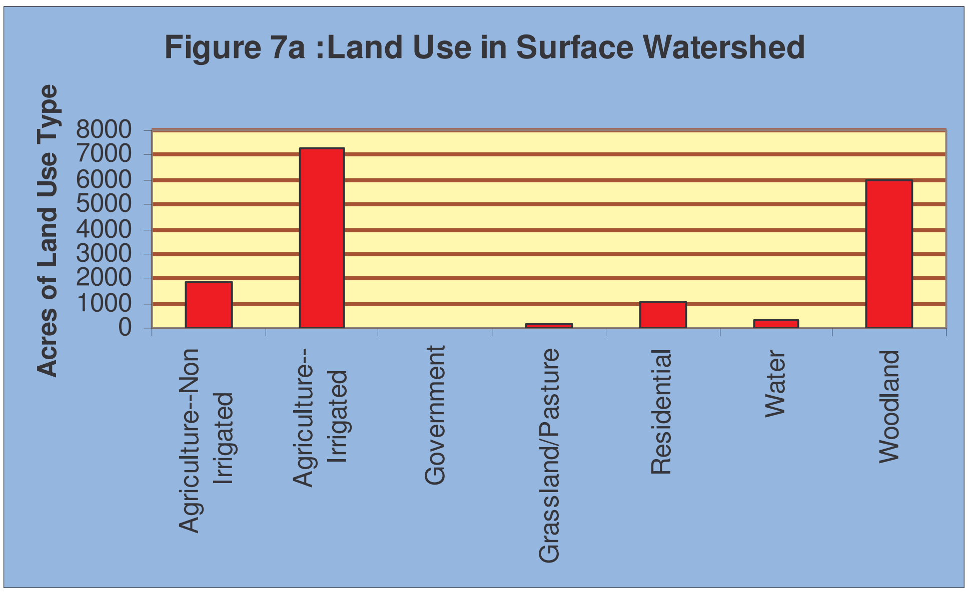
Friendship Lake Ground Watershed Land Use

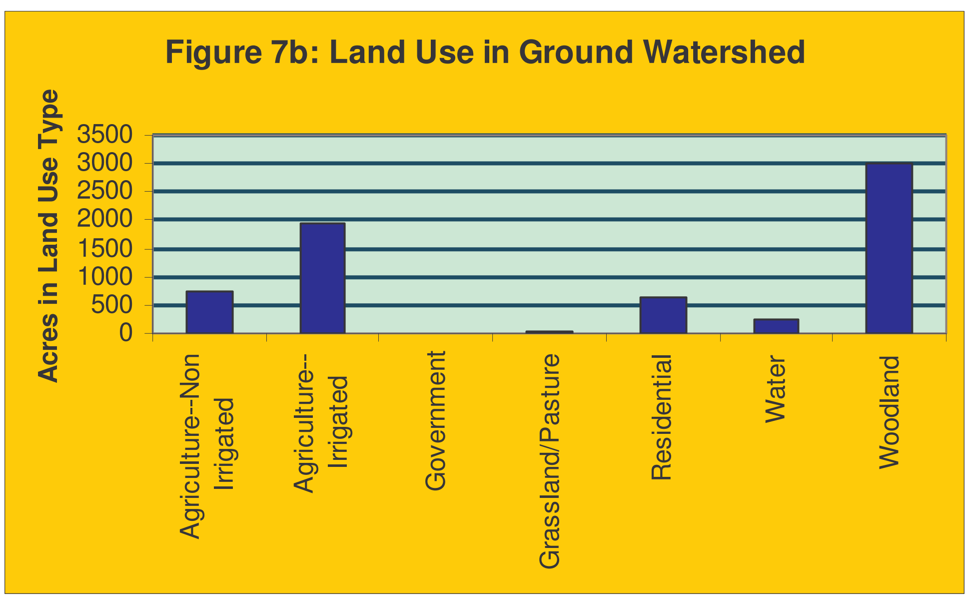


RE: 2/05; revised 3/07

Figure 6b: Land use in Friendship Lake Ground Watershed

When water runs over a surface, it picks up whatever loose pollutants—sediment, chemicals, metals, exhaust gas, etc—are present on that surface and takes those items with it into the lake. Increased development around a lake tends to increase the amount of pollutants being carried into the lake, thus negatively affecting water quality. Residential development areas with lots of one-quarter acre or less may deliver as much as 2.5 pounds of phosphorus per year to the lake for each acre of development.





There are two specific kinds of land use—wetlands and shorelands--that are so important to water quality that they will be separately discussed.

WETLANDS

A number of wetlands are located in the Friendship Lake surface and ground watersheds, especially before and after the lake (Figures 6a & 6b). In the past, wetlands were seen as "wasted land" that only encouraged disease-transmitting insects. Many wetlands were drained and filled in for cropping, pasturing, or even residential development. In the last few decades, however, the importance of wetlands has become evident, even as wetlands continue to decline in acreage.

Wetlands play an important role in maintaining water quality by trapping many pollutants in runoff and flood waters, thus often helping keep clean the water they connect to. They serve as buffers to catch and control what would otherwise be uncontrolled water and pollutants. Wetlands also play an essential role in the aquatic food chain (thus affecting fishery and water recreation), as well as serving as spaces for wildlife habitat, wildlife reproduction and nesting, and wildlife food.

The large areas of wetlands in the Friendship serve as filters and trappers that help keep Little Roche a Cri and Friendship lake as clean as they are. It is essential to preserve these wetlands for the health of Friendship Lake.

Figure 8: Wetland area on Friendship Lake's north shore

SHORELANDS

Friendship Lake has a total shoreline of 5.9 miles (31,152 feet). Much of the lakeshore is in residential use. Many of the areas near the shore are steeply sloped, except at the far northwest end, where the land is flatter and where the beach and boat launch are located. A 2004 shore survey revealed that 75.8% of Friendship Lake's shoreline is vegetated. The rest of the shore is a mix of sand, rock and/or other hard structure. Several areas also have significant erosion occurring, noted in red on the map below. Much of the shore has very steep, sandy banks.

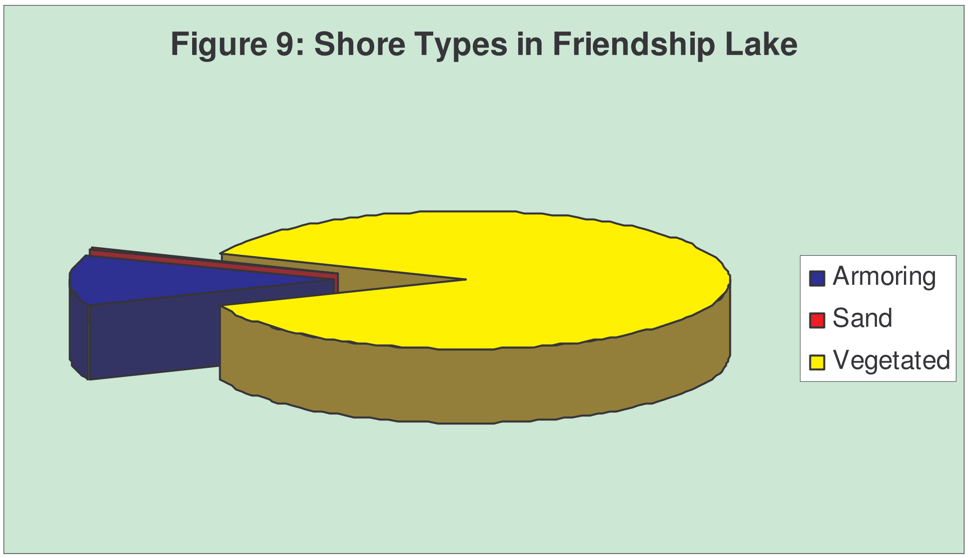
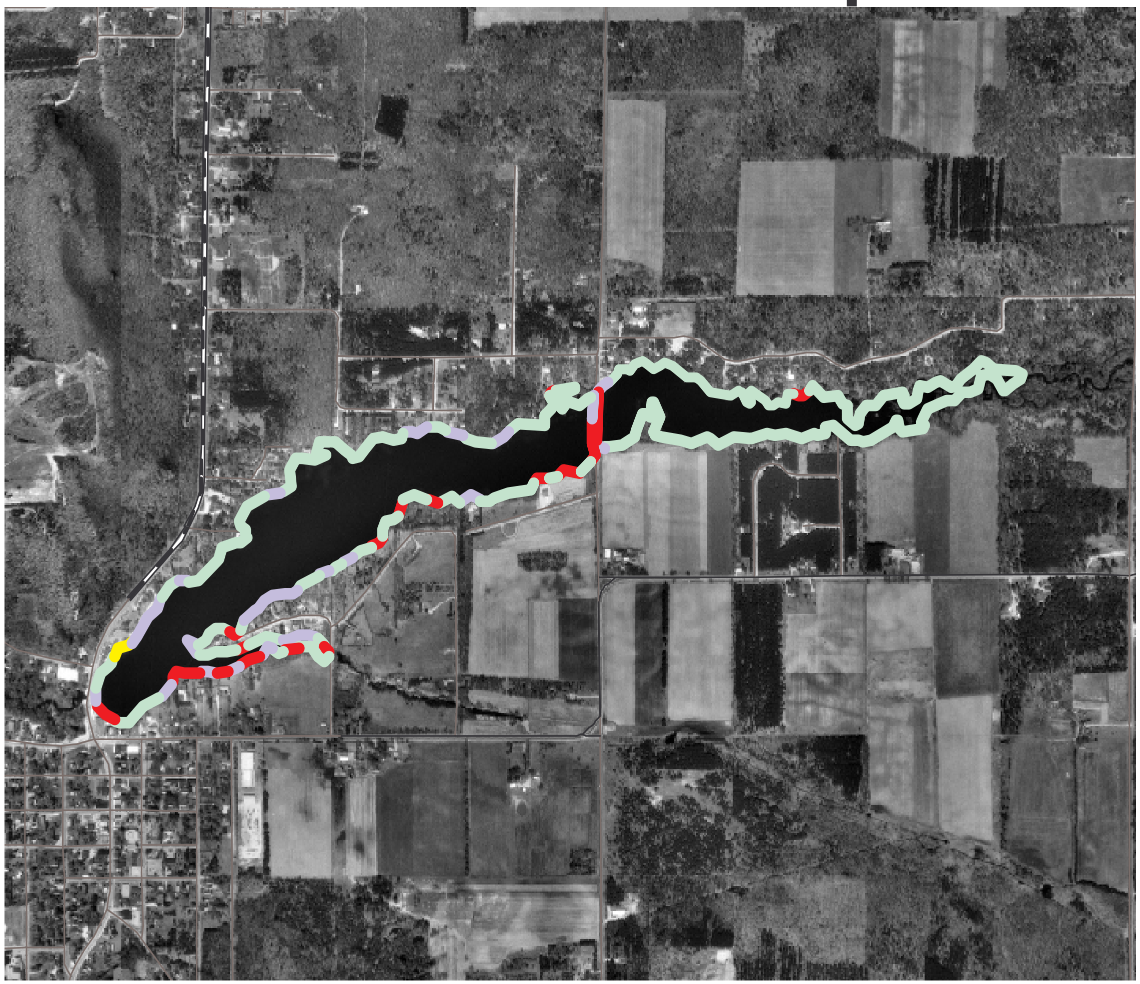
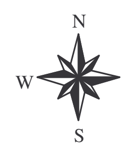


Figure 10: Example of Severe Erosion on Friendship Lake

Shoreline on Friendship Lake



Active Erosion
Hard Structure/Rock/Seawall
Sand/Beach
Vegetated Shore



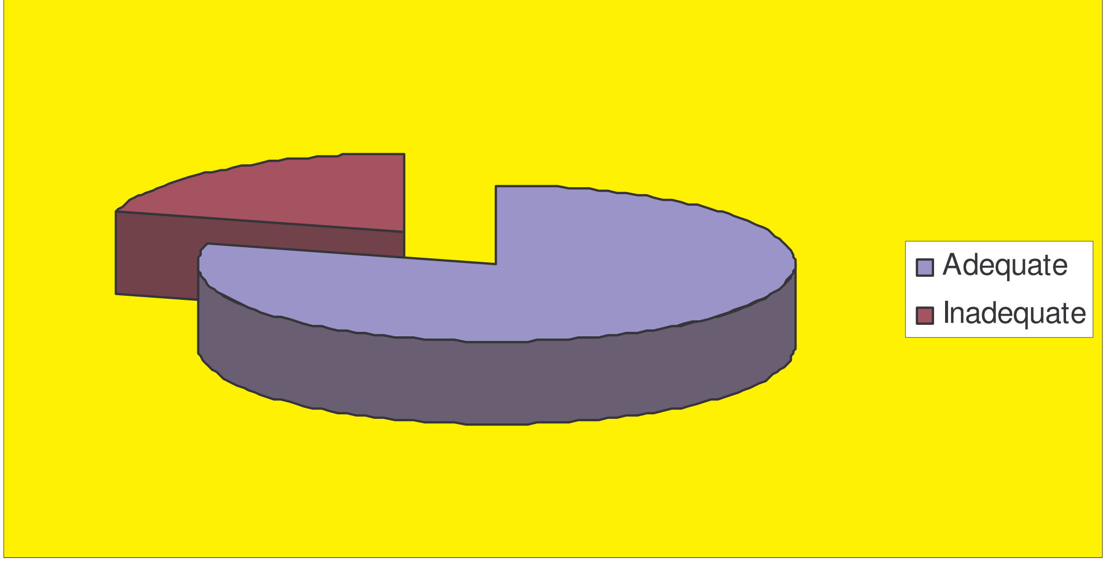
RE:4/05

Figure 11: Friendship Lake Shoreline Map

The Adams County Shoreline Ordinance defines 1000' landward from the ordinary high water mark as "shoreland". Under the ordinance, the first 35 feet landward from the water is a "buffer." Shoreland buffers are an important part of lake protection and restoration. These buffers are simply a wide border of native plants, grasses, shrubs and trees that filter and trap soil & similar sediments, fertilizer, grass clippings, stormwater runoff and other potential pollutants, keeping them out of the lake. A 1990 study of Wisconsin shorelines revealed that a buffer of native vegetation traps 5 to 18 times more volume of potential pollutants than does a developed, traditional lawn or hard-armored shore.

The 2004 inventory included classifying areas of the Friendship Lake shorelines as having "adequate" or "inadequate" buffers (see Figure 12). An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, 79.23% (25565.4 feet) of Friendship Lake's shoreline had an "adequate buffer", leaving 20.77% (6697.6 feet) as "inadequate." Most of the "inadequate" buffer areas were found with mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.

Figure 12: Adequate v. Inadequate Buffer



Vegetated shoreland buffers help stabilize shoreline banks, thus reducing bank erosion. The plant roots give structure to the bank and also increase water infiltration and decrease runoff. A vegetated shore is especially important when shores are steep and soft, as are many of the Friendship Lake shores. Figure 13maps the adequate and inadequate buffers on Friendship Lake.

Figure 13: Friendship Lake Buffer Map

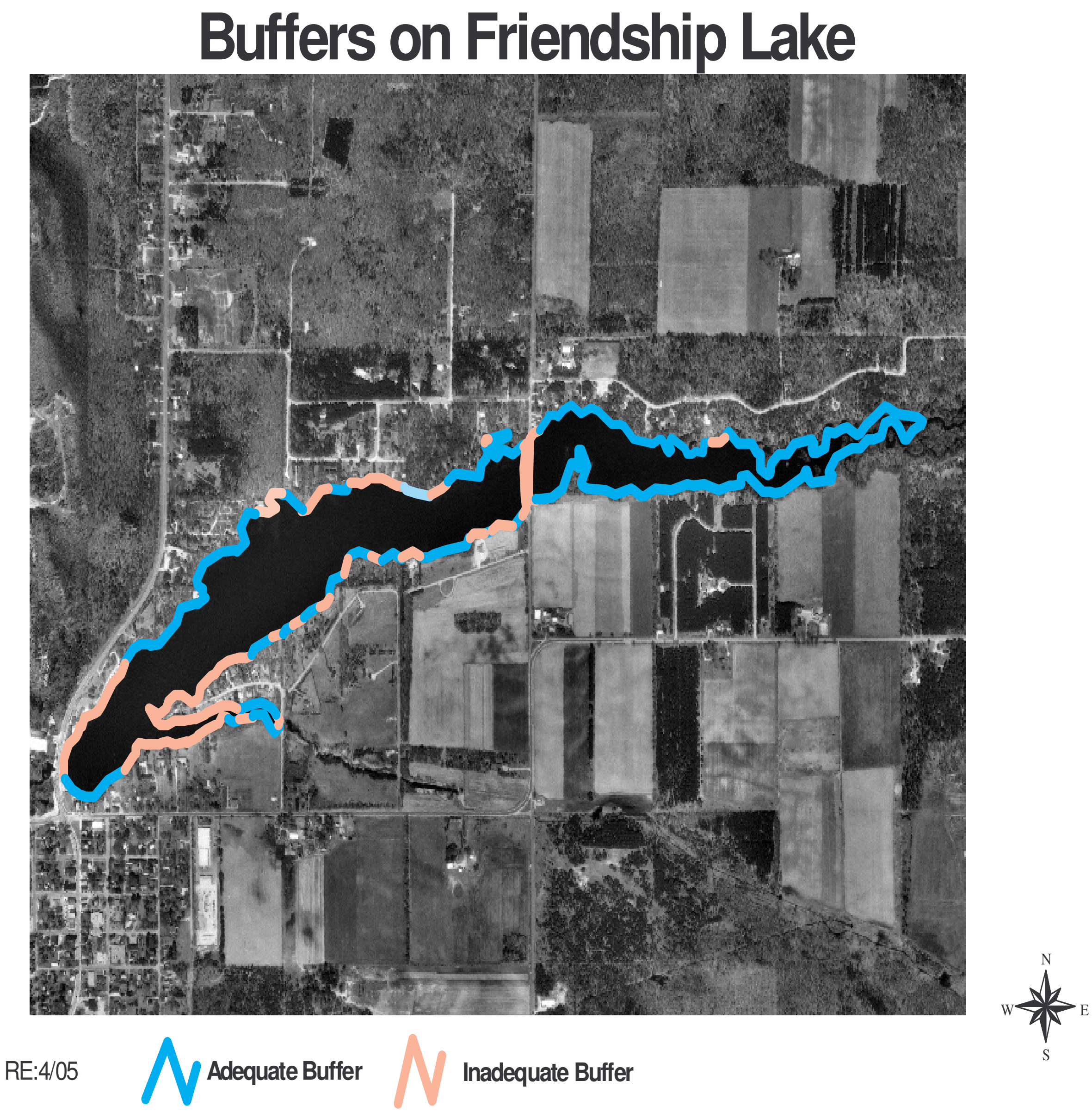


Figure 14: One of Friendship Lake's adequate buffer showing steep vegetated shore

Lakeside buffers also serve as important habitat. Lake edges usually contain aquatic and wetland plants, grading into drier groundcover, then shrubs and trees as one moves inland towards drier land. Buffers provide habitat for many species of water-dependent wildlife, including furbearers, reptiles, birds and insects. Many wildlife species, including birds, small mammals, fish & turtles breed, nest, forage and/or perch in shore buffer areas. Further, 80% of the endangered and threatened species listed spend part of their life in this near-lake buffer area. (Wagner et al, 2006)

When the natural shoreline is replaced by traditional mowed turf-grass lawns, rock, wooden walls or similar installments, bird and animal life, land-based insects, and aquatic insects that hatch or winter on natural shore are negatively impacted. For example, on many Adams County lakes, the non-native aquatic plant, Eurasian Watermilfoil has invaded. There is a weevil native to Wisconsin that weakens Eurasian Watermilfoil by burrowing into and developing within its stems, but that weevil depends on a native-plant shore to overwinter. If the shore is instead covered by rock, seawall or traditional lawn, these weevils will be unavailable for the lake to use as Eurasian Watermilfoil control.

The filtering process and bank stabilization that buffers provide help improve a lake's water quality, including water clarity. Studies in Minnesota, Maine and Michigan have shown that waterfront property value increases for every foot the water clarity of a lake increases. (Krysel et al, 2003).

Figure 15: Example of Inadequate Vegetative Buffer

Figure 16: Example of Adequate Buffer

Natural shoreland buffers serve important cultural functions. They enhance the lake's aesthetics. Studies have shown that aesthetics rank high as one of the reasons people visit or live on lakes. Shore buffers can provide visual & audio privacy screens for homeowners from other neighbors and/or lake users.

Adequate buffers on Friendship Lake could be easily installed on most of the inadequate areas by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or—if something more controlled or aesthetically pleasing was desired—by planting native seedlings sufficient to fill in the first 35 feet or using biologs to protect the shore that are vegetated. Where areas are deeply eroded, shaping, revegetating and protecting the shores will be necessary to prevent further erosion.

WATER QUALITY

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information Friendship Lake. Part of the information was gained from periodic water sampling done by Adams County LWCD. Historic information about water testing on Friendship Lake was also obtained from the WDNR in a series of 1994 tests and from Self-Help Monitoring records from 1994-2004..

Phosphorus

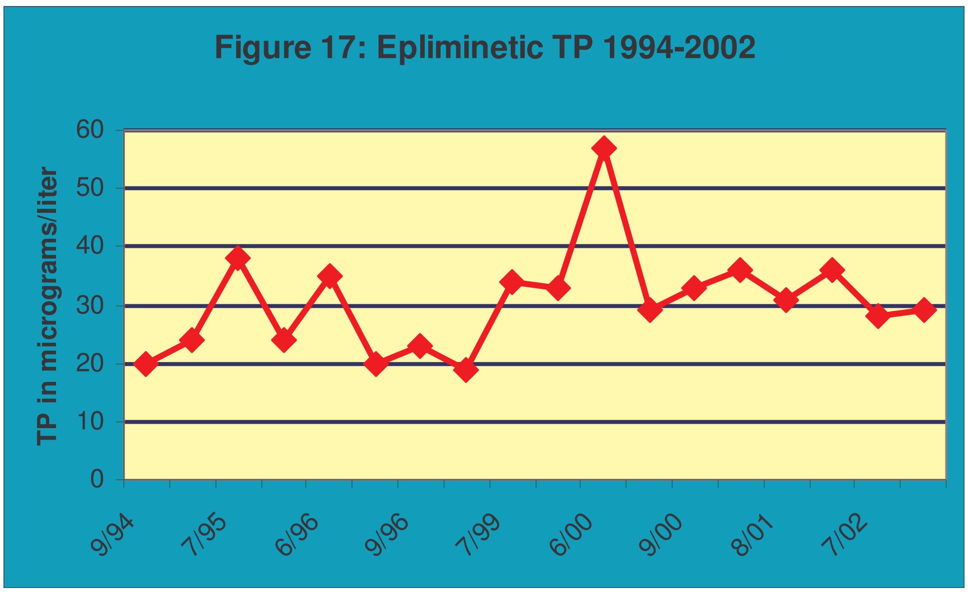
Most lakes in Wisconsin, including Friendship Lake, are phosphorus-limited lakes: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects. One pound of phosphorus can produce as much as 500 pounds of algae.

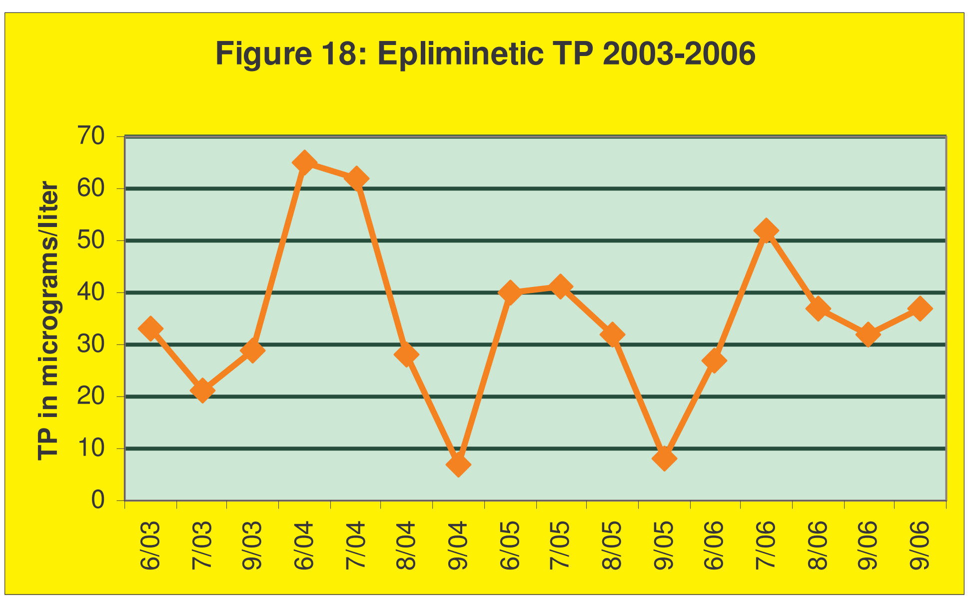
Phosphorus is not an element that occurs in high concentration naturally, so any lake that has significant phosphorus readings must have gotten that phosphorus from outside the lake or from internal loading. Some phosphorus is deposited onto the lake from atmospheric deposition, especially from soil or other particles in the air carrying phosphorus. A lake that includes a flooded wetland area may have a significant amount of phosphorus being released during the flushing of the wetland area. Phosphorus may accumulate in sediments from dying animals, dying aquatic plants and dying algae. If the bottom of the lake becomes anoxic (oxygen-depleted), chemical reactions may cause phosphorus to be released to the water column.

Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For an impoundment lake like Friendship Lake, a total phosphorus concentration below 30 micrograms/liter tends to prevent nuisance algal blooms. Friendship Lake's growing season (June-September) surface average total phosphorus level of 36 micrograms/liter is over to the level at which nuisance algal blooms can be expected. And areas of Friendship Lake do have nuisance-level algal blooms. In 2007, the entire lake turned green from a large algal bloom.

Since phosphorus is usually the limited factor, measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth.

The 2004-2006 summer average phosphorus concentration in Friendship Lake was 36 micrograms/liter. This places Friendship Lake in the "fair" water quality section for impoundments, and in the "mesotrophic" level for phosphorus. The total epilimnetic phosphorus levels are slowly creeping up in Friendship Lake. The average growing season eplimnetic total phosphorus from 1994-1996 was 26.29 micrograms/liter. It crept up to 29.3 micrograms/liter average between 1999-2003. By 2004-2006, it crept up to 36 micrograms/liter.





As the above graphs (Figures 17 and 18) indicate, the growing season total phosphorus levels have varied and often registered above the level recommended to avoid nuisance algal blooms. Except for a spike in June 2005, the eplimnetic total phosphorus levels since August 2004 stayed below 40 micrograms/liter. Especially due to the increasing epilimnetic total phosphorus levels, phosphorus should continue to be monitored and steps should be taken to reduce the phosphorus levels in the lake.

Groundwater testing of various wells around Friendship Lake was done by Adams County LWCD and included a test one year for total phosphorus levels in the groundwater coming into the lake. The average TP level in the wells tested 19.6 micrograms/liter, considerably lower than the lake surface water results. Even if some of this phosphorus enters the lake from groundwater, it is unlikely to contribute significantly to the rising phosphorus levels.

Land use plays a major role in phosphorus loading. A key component of the computer models used is the phosphorus budget, that is, the estimated amount of phosphorus delivered to the lake from each land use type annually. The land uses that contribute the most phosphorus are non-irrigated agriculture and residences. Using the current land use data, as well as phosphorus readings from 2004 through 2006 water sampling, a phosphorus loading prediction model was run for Friendship Lake. The current results are shown in the table below:

Figure 19: Current Phosphorus Loading by Land Use

MOST LIKELY CURRENT PHOSPHORUS LOADING		
Land Use Type	**% Total**	**P in lbs/acre/yr**
Irrigated Agriculture	69.20%	1306.18
Non-Irrigated Agriculture	14.50%	273.91
Pasture/Grass	0.50%	9.81
Residential	1.90%	35.69
Woodlands	5.70%	107.96
Other Water	0.60%	10.71
Ground Watershed	6.40%	119.55
Commercial	0.10%	2.68
Lake Surface	0.30%	6.25
Septics	0.80%	14.72
Total	100.00%	1887.45

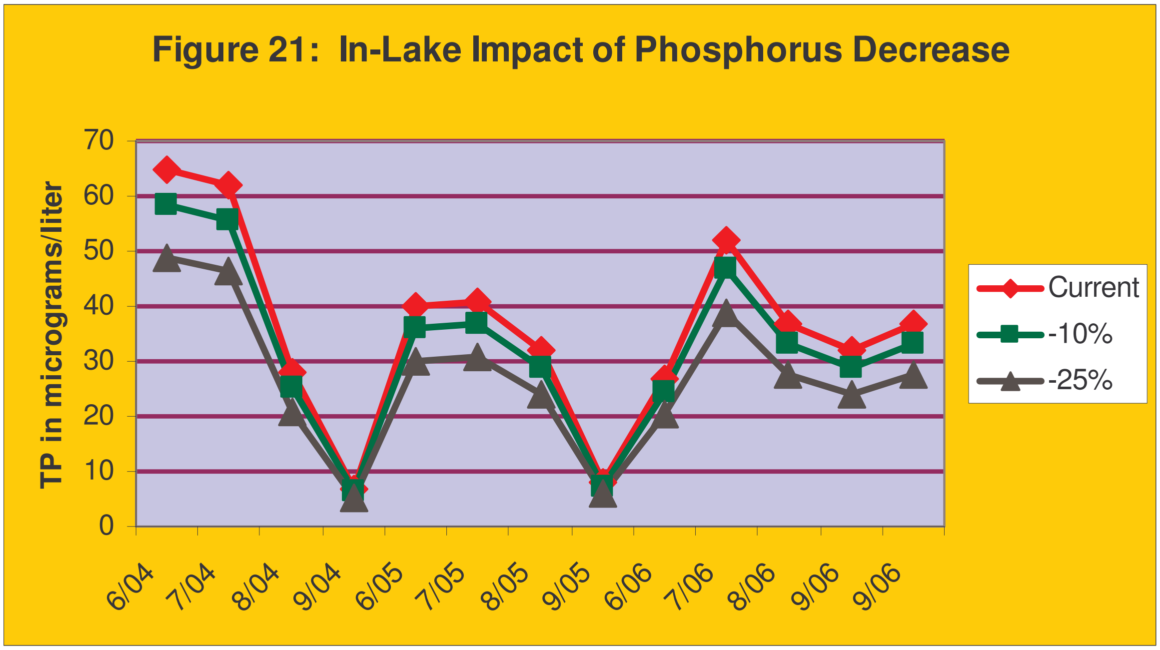
Phosphorus deposits such as that from flooded wetlands or from atmospheric deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Circumstances such as increased impervious surface, lawns mowed to water's edge, disturbance of shore areas, improperly-functioning septic systems and removal of native vegetation can greatly increase the volume and content of runoff—and thus increase the volume of phosphorus entering the lake. Many of these practices can also increase the concentration of phosphorus entering the lake, by runoff or other methods of entry.

The models were run using not only the current known phosphorus readings in the lake, but also representing decreases or increases of human-controlled phosphorus input by 10%, 25%, and 50%. Just a 10% reduction of the human-impacted phosphorus would reduce the overall load by 168.29 pounds/acre/year. This figure may not seem like much---until you calculate that one pound of phosphorus can result in up to 500 pounds of algae. A 10% reduction in these three areas could result in up to 84,145 pounds less of algae per acre per year!

Figure 20: Impact Reductions in Phosphorus Loading

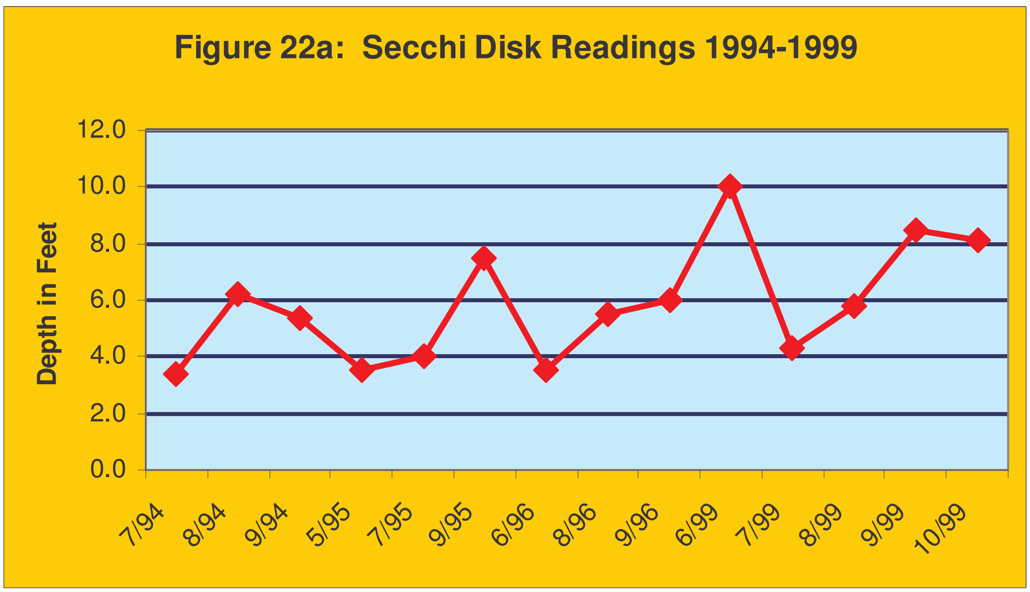
	-50%	-25%	-10%	current
Irrigated Agriculture	653.07	979.64	1175.56	1306.18
Non-Irrigated Agriculture	136.96	205.43	246.51	273.91
Pasture/Grass	9.81	9.81	9.81	9.81
Residential	17.85	28.50	32.12	35.69
Woodlands	107.96	107.96	107.96	107.96
Other Water	10.71	10.71	10.71	10.71
Ground Watershed	94.97	107.06	114.31	119.55
Commercial	2.68	2.68	2.68	2.68
Lake Surface	6.25	6.25	6.25	6.25
Septics	4.91	11.04	13.25	14.72
Total	1045.16	1469.08	1719.17	1887.46

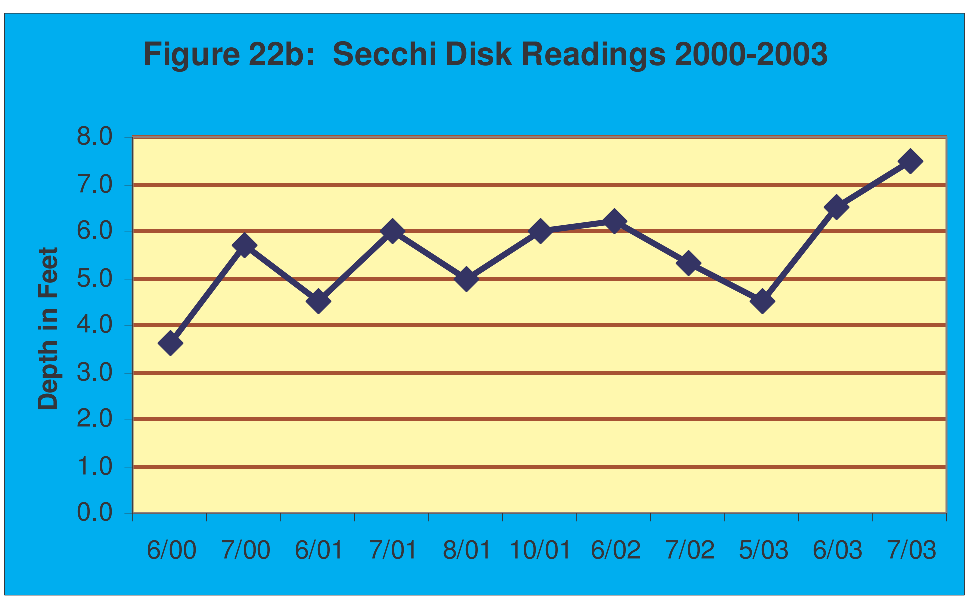
Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% would improve Friendship Lake water quality by 2 to 10 micrograms of phosphorus/liter; a 25% reduction would save 6 to 19 micrograms/liter (see Figure 21). Reductions of 25% could put the lake low enough (27 micrograms/liter, under the 30 micrograms/liter recommended to avoid nuisance algal blooms) in total phosphorus levels that algal blooms would be greatly reduced. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Friendship Lake's health for future generations.



Water Clarity

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Friendship Lake in 2004-2006 was 6.52 feet. This is good water clarity, putting Friendship Lake into the "mesotrophic" category for water clarity.





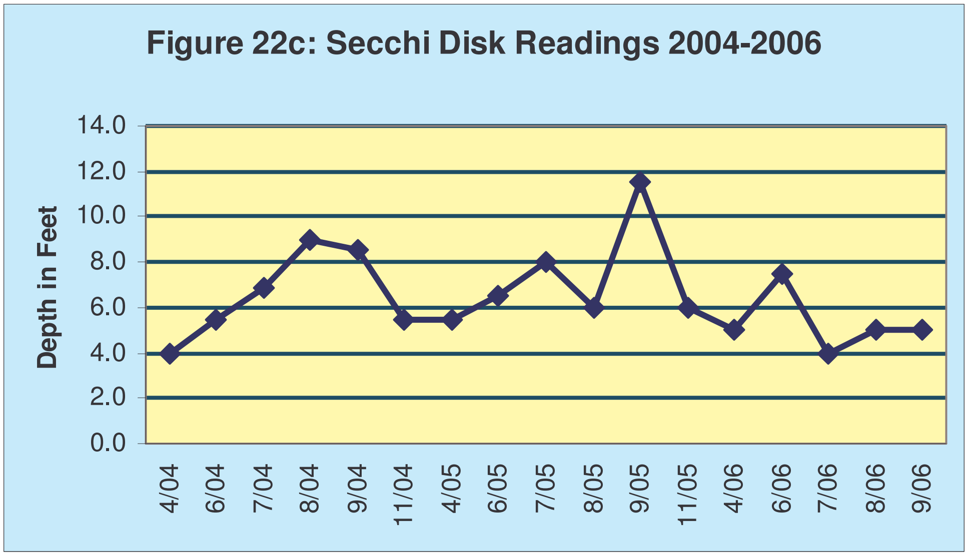
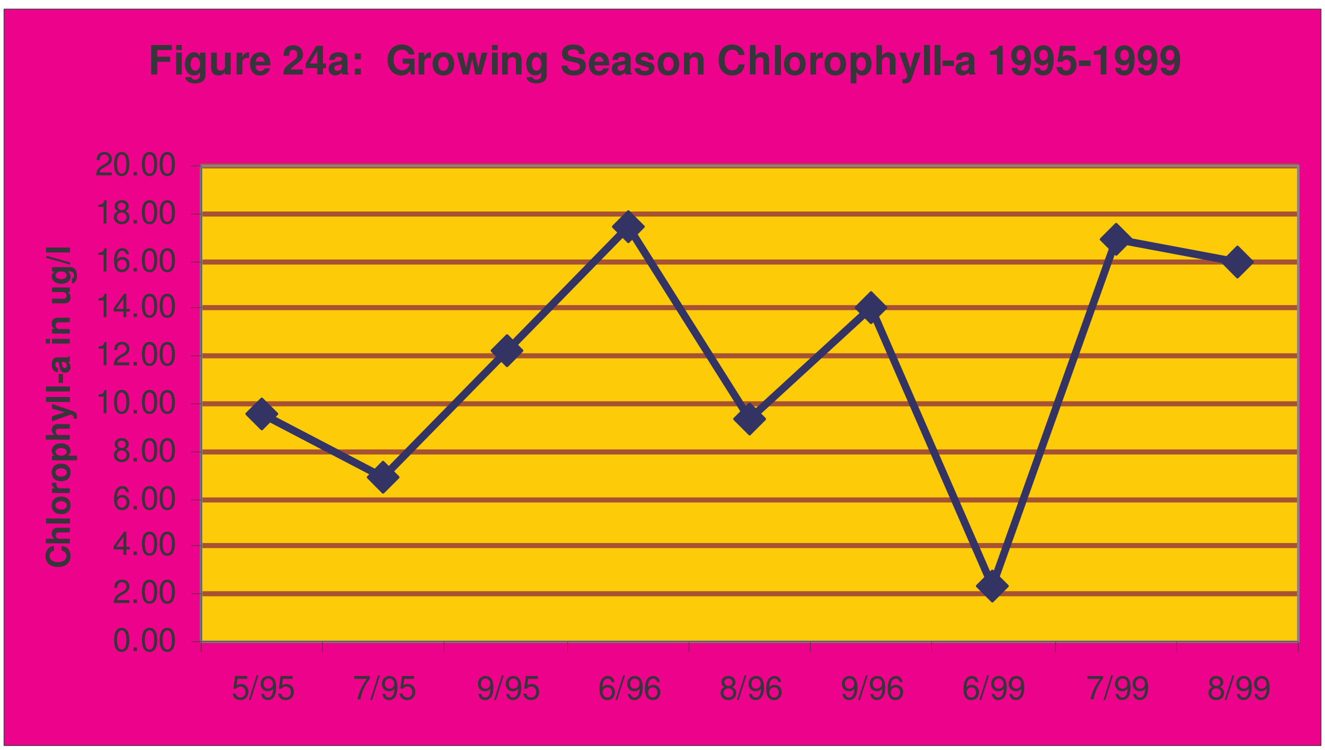


Figure 23: Photo of Testing Water Clarity with Secchi Disk

Chlorophyll a

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll a in lake water depends greatly on the amount of algae present; therefore, chlorophyll-a levels are commonly used as a water quality indicator. The 2004-2006 summer (June-September) average chlorophyll concentration in Friendship Lake was 11.5 micrograms/liter. Such an algae concentration places Friendship Lake at the "fair" level for chlorophyll a results.

Chlorophyll-a averages have varied considerably since 1995, the first year for which records were found, as seen on the graph below (Figure 24a, b, c).



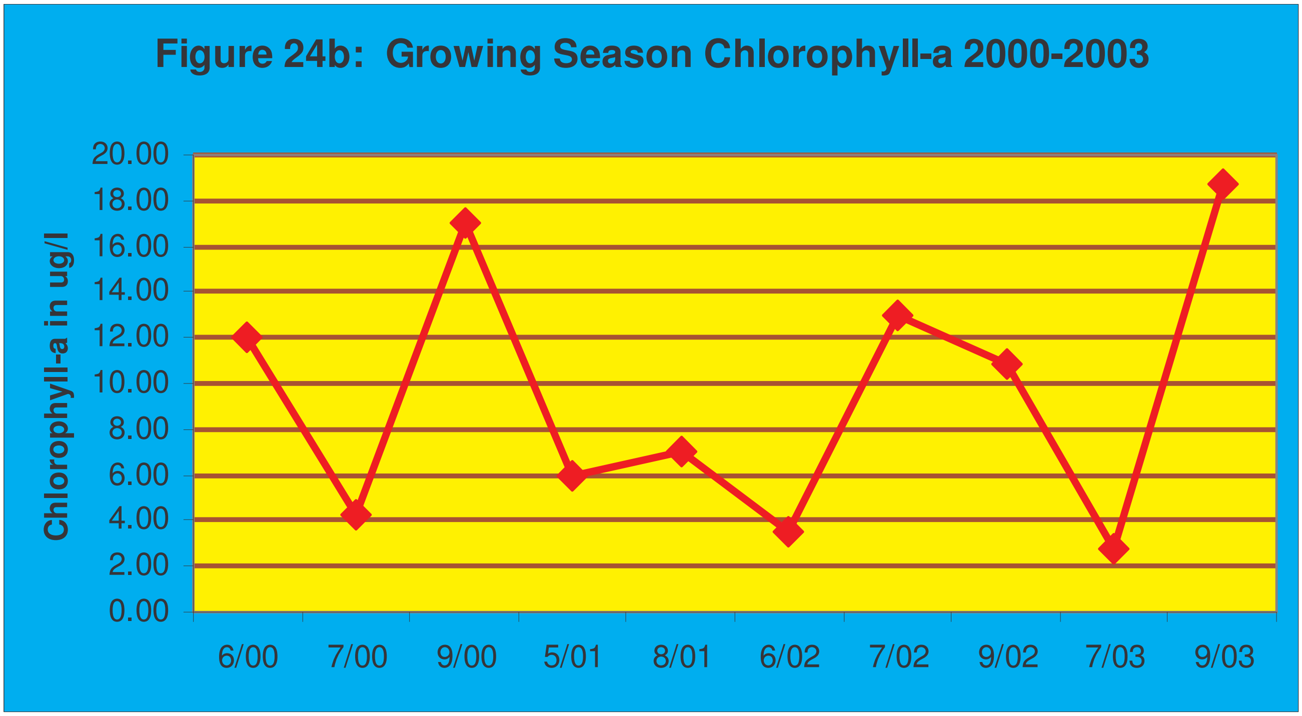


Figure 24b: Growing Season Chlorophyll-a 2000-2003
Chlorophyll-a in ug/l
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
6/00
7/00
9/00
5/01
8/01
6/02
7/02
9/02
7/03
9/03

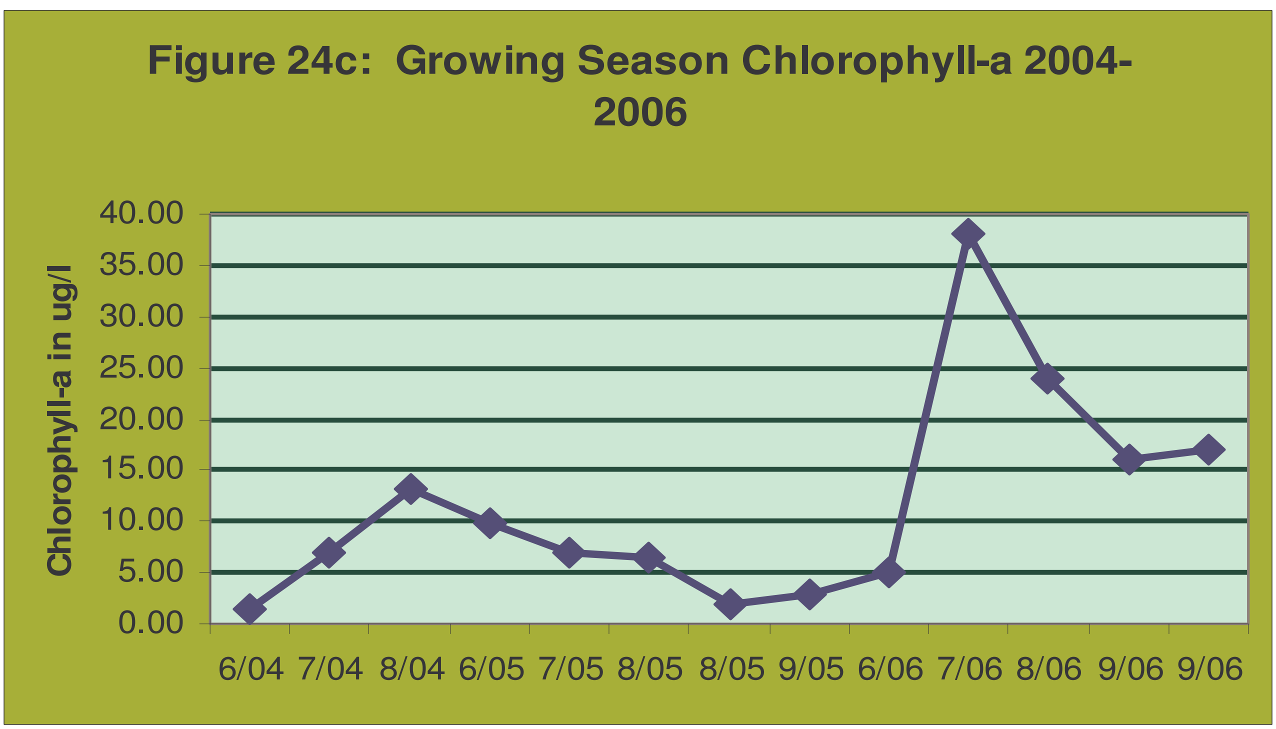


Figure 24c: Growing Season Chlorophyll-a 2004-2006
Chlorophyll-a in ug/l
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
6/04
7/04
8/04
6/05
7/05
8/05
8/05
9/05
6/06
7/06
8/06
9/06
9/06

Dissolved Oxygen

Oxygen dissolved in the water is essential to all aerobic aquatic organisms. The oxygen in a lake comes from the atmosphere and from the process of photosynthesis. Aquatic plants and algae consume carbon dioxide and respirate oxygen back into the lake water. The distribution of oxygen within a lake is affected by many factors, including water circulation, water stratification, winds or storms, air temperature; water temperature, nutrient availability, and the density and location of algae and/or aquatic plants. During the summers of 2004, 2005 and 2006, dissolved oxygen levels didn't usually go below levels 5 mg/l, the appropriate level for good fish survival. The charts (Figures 25a, b, c) below show the annual (2004-2006) variations in dissolved oxygen levels in milligrams/liter, depth in feet and months of the year:

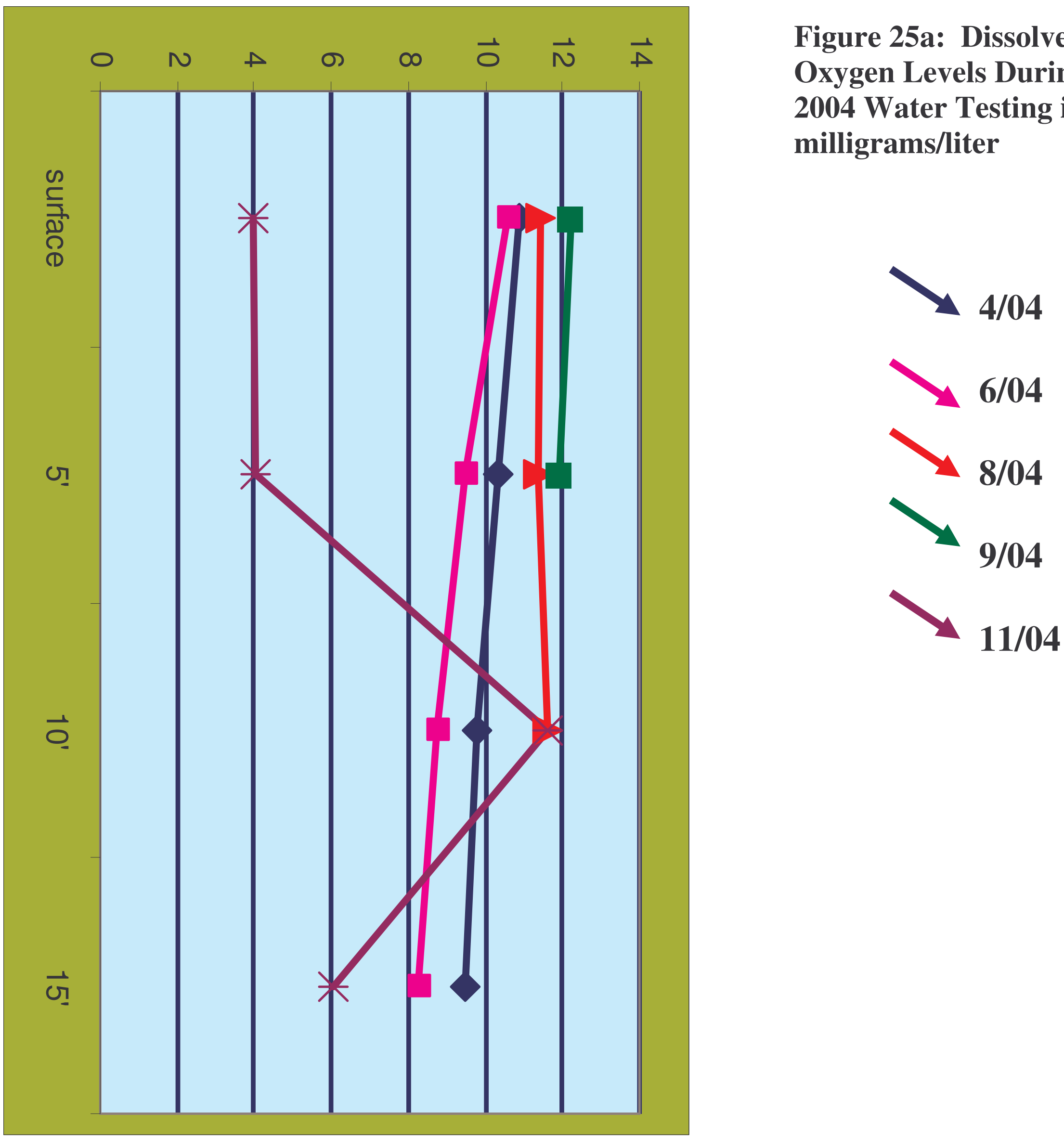
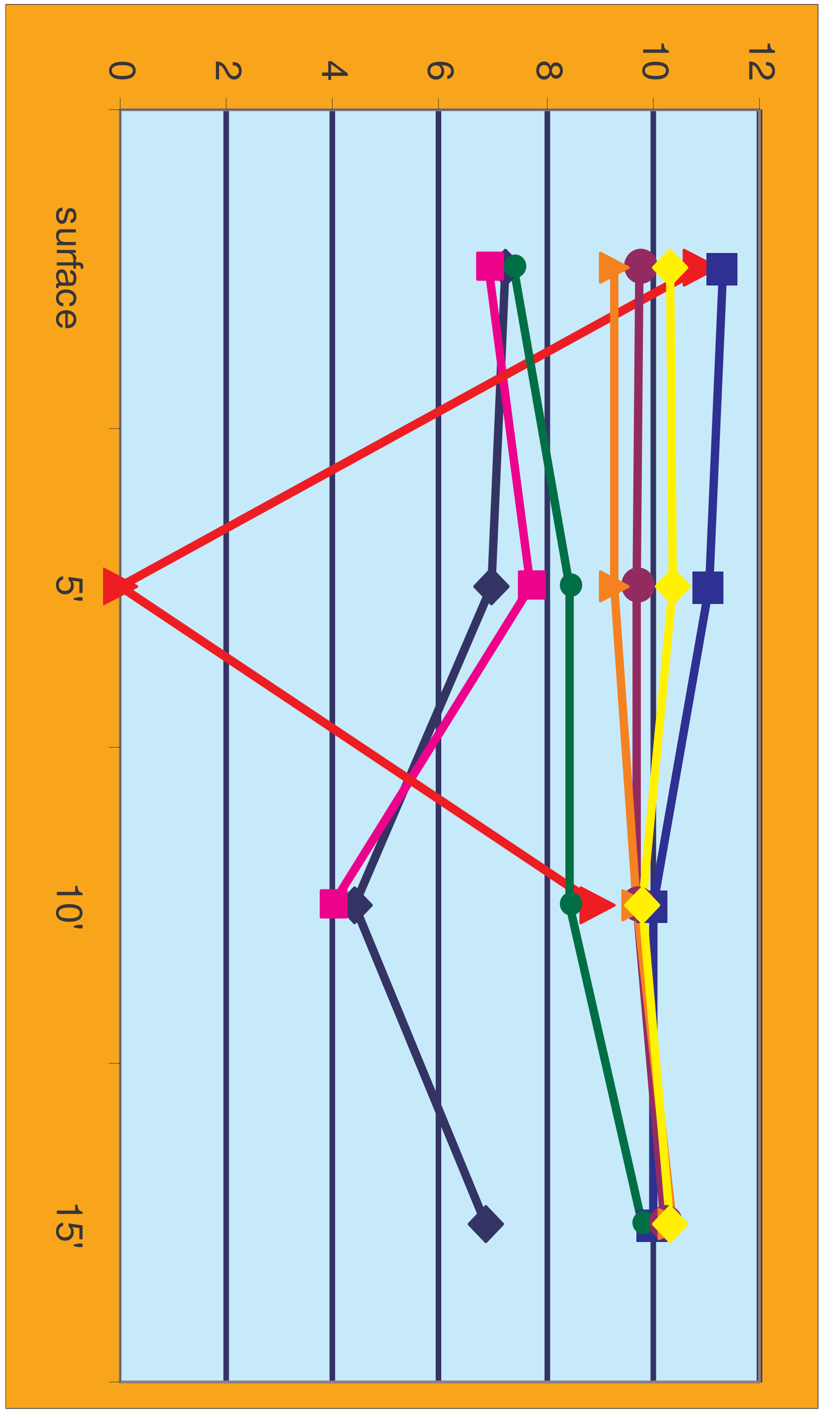


Figure 25a: Dissolved Oxygen Levels During 2004 Water Testing in milligrams/liter

Figure 25b: Dissolved Oxygen Levels During 2005 Water in milligrams/liter



2/05

4/05

6/05

7/05

8/05

8/05

9/05

11/05

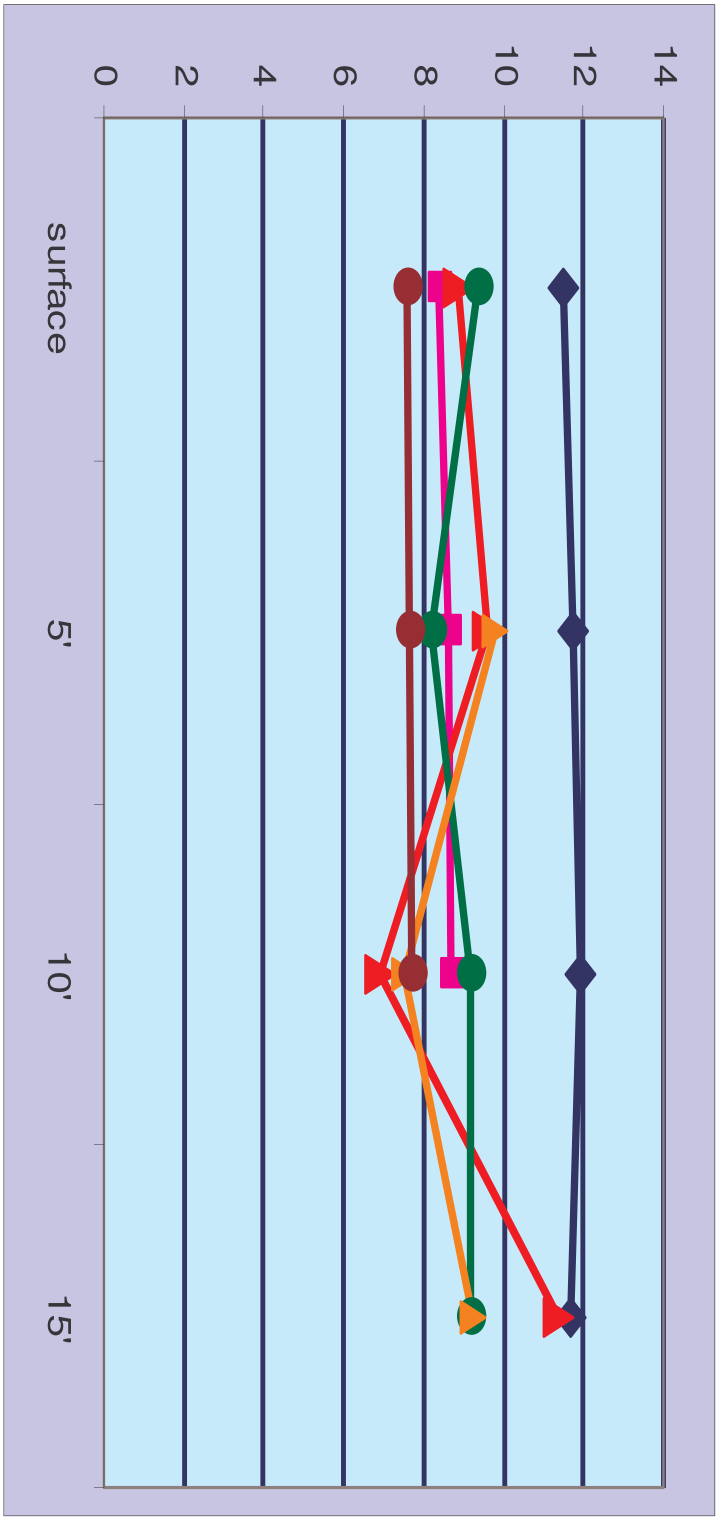


Figure 25c: Dissolved Oxygen Levels During 2006 Water Testing in milligrams/liter

4/06

6/06

7/06

8/06

9/06

9/06

In deeper lakes, when the surface waters have cooled in autumn and water density throughout the water column is the same, the water column mixes vertically, a process known as "fall turnover." Since Friendship Lake is such a shallow lake, it does not stratify and thus does not turnover in either the spring or fall.

Further, since flowing stream goes through the south side of Friendship Lake, some open water is common throughout the winter on part of the lake. This probably allows oxygen levels to stay elevated—even the winter dissolved oxygen readings at Friendship Lake were 6.8 mg/l, over the amount needed by fish.

Figure 26: Photo of a Lake with Algal Bloom

Water Hardness, Alkalinity and pH

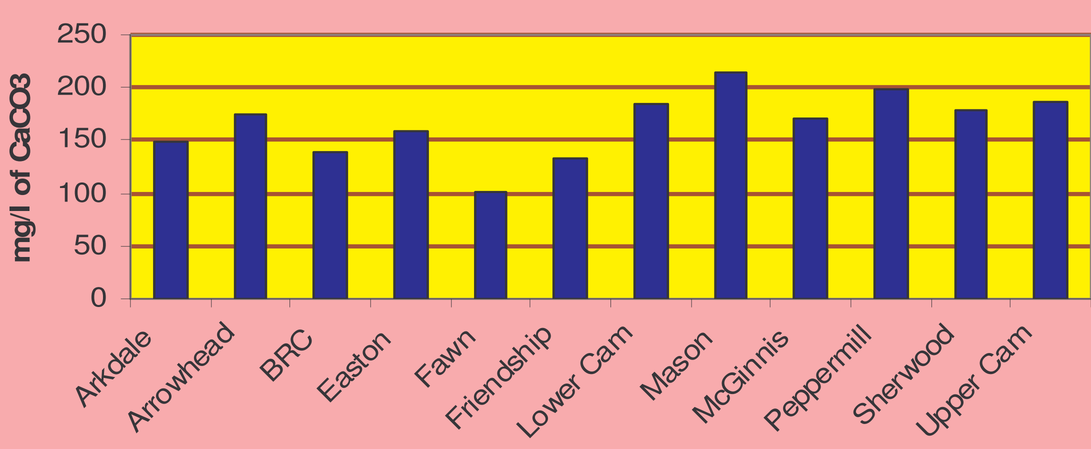
Testing done by Adams County LWCD on Friendship Lake included annual testing for water alkalinity and water hardness. Hardness and alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water & these materials.

Level of Hardness	Mg/l CaCO3
SOFT	0-60
MODERATELY HARD	61-120
HARD	121-180
VERY HARD	>180

Figure 27: Hardness Table

One method of evaluating hardness is to test the water for the amount of calcium carbonate (CaCO3) it contains. The surface water of all of the public access lakes in Adams County have water that is moderately hard to very hard, whether they are impoundments (man-made lakes) or natural lakes. In 2005 and 2006, random samples were also taken of wells around Friendship Lake to measure the hardness of the water coming into the lake through groundwater. Hardness in the groundwater ranged from 104 (moderately hard) to 184 (very hard), with an average of 129.9 mg/l. The hardness in both surface and groundwater is likely due to the underlying bedrock in Adams County, which is mostly sandstone with pockets of dolomite and shale.

Figure 28: Hardness in Adams County Impoundments



As the graph (Figure 28) shows, Friendship Lake surface water testing results showed "hard" water (average 133 mg/l $CaCO_3$), less than the overall hardness average impoundments in Adams County of 166 mg/l of Calcium Carbonate. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. "Acid rain" has long been a problem with lakes that had low alkalinity level and high potential sources of acid deposition.

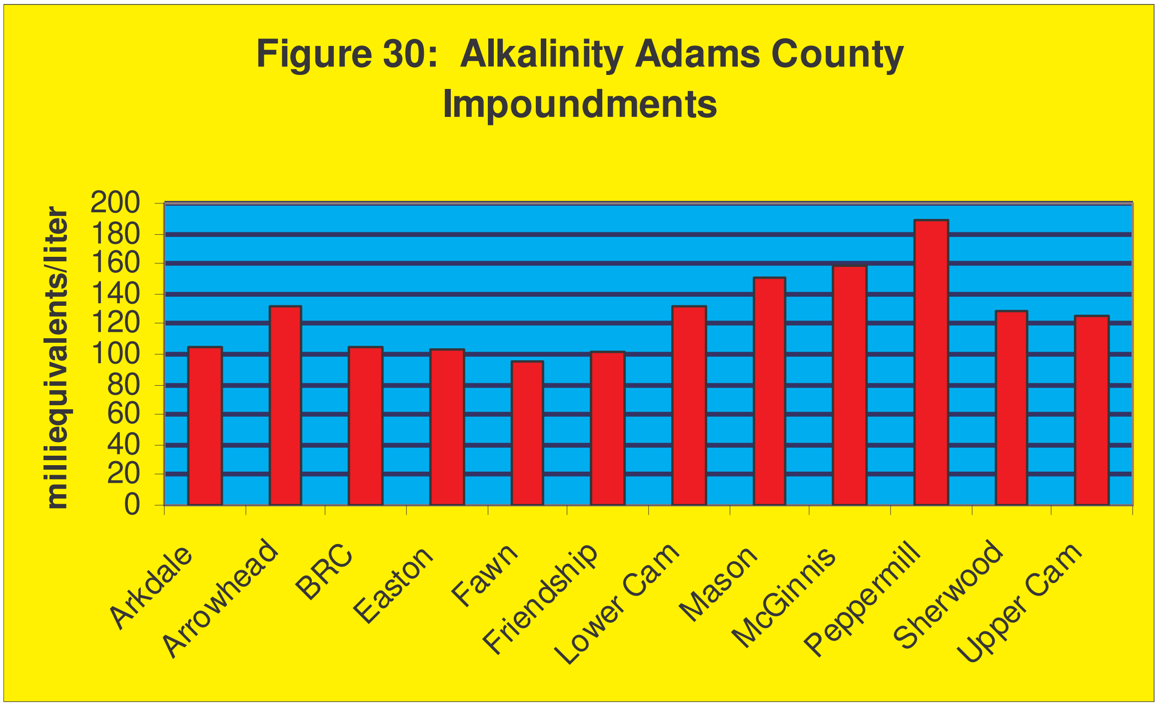
Acid Rain Sensitivity	ueq/l $CaCO_3$
High	0-39
Moderate	49-199
Low	200-499
Not Sensitive	>500

Figure 29: Acid Rain Sensitivity

Well water testing results ranged from 80 ueq/l to 156 ueq/l in alkalinity, with an average of 110.4 ueq/l. This is higher than the surface water average of 98.4. Friendship Lake's potential sensitivity to acid rain is moderate, but luckily for Adams County, the acid deposition rate is very low, probably due to the little industrialization in the county.

Alkalinity also affects the pH level of lake water. The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid bog lakes to 8.4 in hard water, marl lakes.

Some of the minerals that become available under low pH, especially the metals aluminum, zinc and mercury, can inhibit fish reproduction and/or survival. Even what seems like a small variance in pH can have large effects because the pH scale is set up so that every 1.0 unit change increases acidity tenfold, i.e., water with a pH of 7 is 10 times more acid than water with pH of 8. Mercury and aluminum are not only toxic to many kinds of wildlife; they can also be toxic to humans, especially those that eat tainted fish.



The testing occurring from 2004-2006 also included regular monitoring of the pH at several depths in Friendship Lake. As is common in the lakes in Adams County, Friendship Lake has pH levels starting at just under neutral (6.95) at 15' depth and increasing in alkalinity as the depth gets less, until the surface water pH averages 7.88. A lake's pH level is important for the release of potentially harmful substances and also affects plant growth, fish reproduction and survival. Most plants grow best at pH levels between 5.5 and 8.

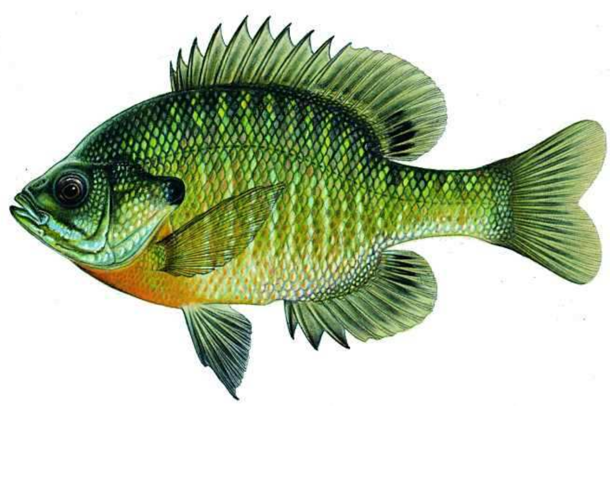
More importantly for many lakes, fish reproduction and survival are very sensitive to pH levels. The chart below indicates the effect of pH levels under 6.5 on fish (Figure 31):

Figure 31: Effects of pH Levels on Fish

Water pH	Effects
6.5	walleye spawning inhibited
5.8	lake trout spawning inhibited
5.5	smallmouth bass disappear
5.2	walleye & lake trout disappear
5	spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	perch spawning inhibited
3.5	perch disappear
3	toxic to all fish

No pH levels taken in Friendship Lake between 2004-2006 fell below the pH level that inhibits walleye reproduction. A lake with a neutral or slightly alkaline pH like Friendship Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Friendship Lake. Friendship Lake has a good pH level for fish reproduction and survival.

Figure 32: Abundant Fish in Friendship Lake:
Top: Largemouth Bass
bottom: Bluegill



Other Water Quality Testing Results

CALCIUM and MAGNESIUM: Calcium is required by all higher plants and some microscopic lifeforms. Magnesium is needed by chlorophyllic plants and by algae, fungi and bacteria. Both calcium and magnesium are important contributors to the hardness of a lake's waters. Magnesium elevated about 125 mg/l may have a laxative effect on some humans. Otherwise, no health hazards to humans and wildlife are known from calcium and magnesium. The average Calcium level in Friendship Lake's water during the testing period was 28.08 mg/l. The average Magnesium level was 13.58 mg/l. Both of these are low-level readings.

CHLORIDE: Chloride does not affect plant and algae growth and is not known to be harmful to humans. It isn't common in most Wisconsin soils and rocks, so is usually found only in very low levels in Wisconsin lakes. However, the presence of a significant amount of chloride over a period of time indicates there may be negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. An increased chloride level is thus an indication that too many nutrients are entering the lake, although the level has to be evaluated compared to the natural background data for chloride. The average chloride level found in Friendship Lake during the testing period was 4.43 mg/l, above the natural level of chloride in this area of Wisconsin. Further investigation as to the cause of such elevations needs to be performed.

NITROGEN: Nitrogen is necessary for plant and algae growth. A lake receives nitrogen in various forms, including nitrate, nitrite, organic, and ammonium. In Wisconsin, the amount of nitrogen in a lake's water often corresponds to the local land use. Although some nitrogen will enter a lake through rainfall from the atmosphere, that coming from land use tends to be in higher concentrations in larger amounts, coming from fertilizers, animal and human wastes, decomposing organic matter, and surface runoff. For example, the growth level of the exotic aquatic plant, Eurasian Watermilfoil (*Myriophyllum spicatum*) has been correlated with fertilization of lake sediment by nitrogen-rich spring runoff.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Friendship Lake combination spring levels from 2004 to 2006 averaged 1.83 mg/l, far above the .3 mg/l predictive level for nitrogen-related algal blooms. Friendship Lake has a significant ongoing problem with large and frequent algal blooms during the growing season.

SODIUM AND POTASSIUM: These elements occur naturally only in low levels in Wisconsin waters and soils. Their presence may indicate human-caused pollution. Sodium is found with chloride in many road salts and fertilizers and is also found in human and animal waste. Potassium is found in many fertilizers and also found in animal waste. Increasing levels or one or both of these elements can indicate possible contamination from damaging pollutants. High levels of sodium have also been found to influence the development of a large population of cyanobacteria, some of which can be toxic to animals and humans. Some health professionals have suggested that sodium levels over 20 mg/l may be harmful to heart and kidney patients if ingested. Both sodium and potassium levels in Friendship Lake are very low: the average sodium level was 1.83 mg/l; the average potassium reading .98 mg/l.

SULFATE: In low-oxygen waters (hypoxic), sulfate can combine with hydrogen and becomes the gas hydrogen sulfate (H2S), which smells like rotten eggs and is toxic to most aquatic organisms. Sulfate levels can also affect the metal ions in the lake, especially iron and mercury, by binding them up, thus removing them from the water column. To prevent the formation of H2S, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Friendship Lake sulfate levels averaged 16.43 mg/l during the testing period, above the level for H2S formation, but below the health advisory level.

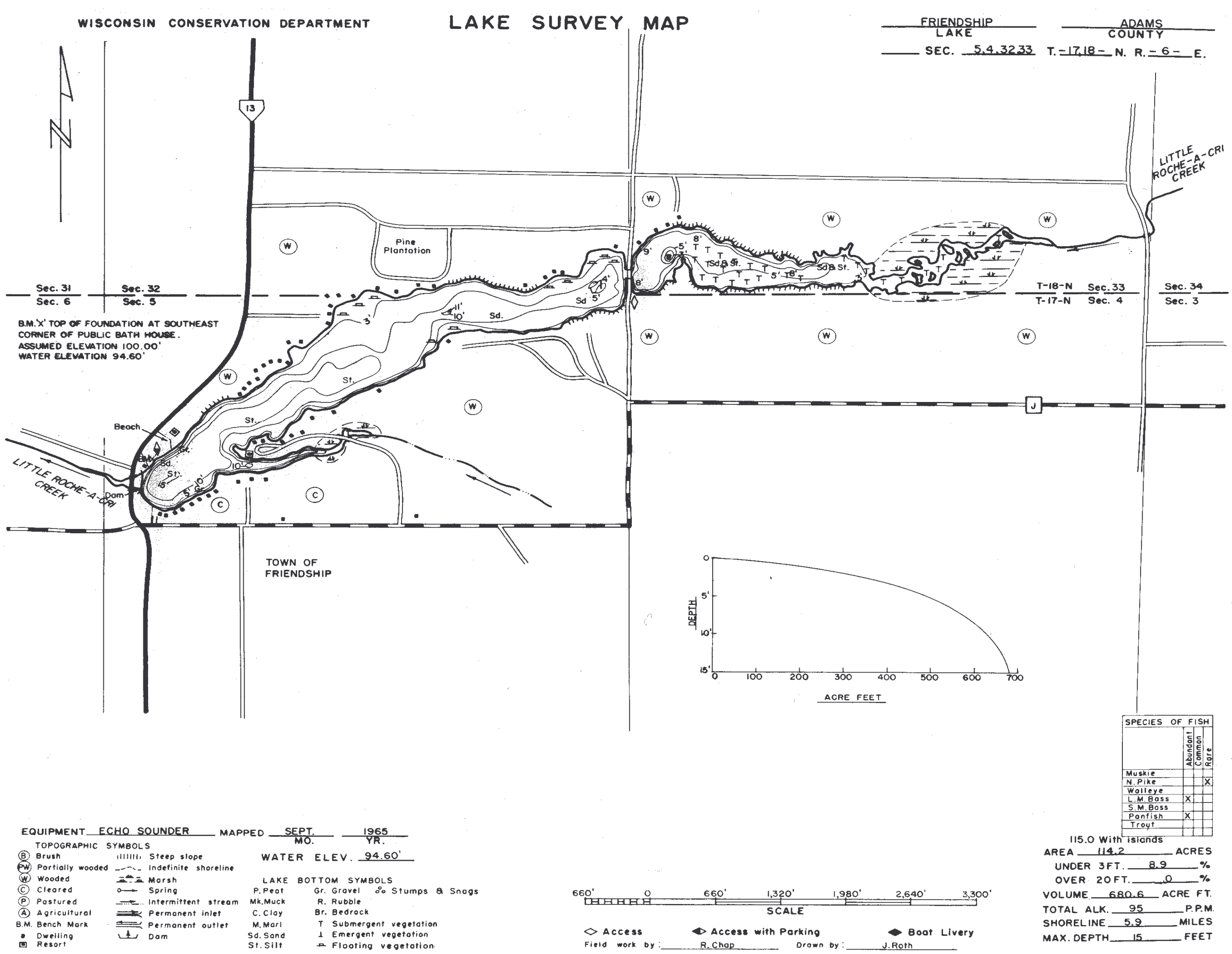
TURBIDITY: Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Turbid water may mask the presence of bacteria or other pollutants because the water looks murky or muddy. In general, turbidity readings of less than 5 NTU are best. Very turbid waters may not only smell, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Friendship Lake's waters were 2.06 NTU in 2004, 2.13 NTU in 2005, and 3.54 NTU in 2006—all below the level of concern.

Figure 33: Examples of Very Turbid Water

HYDROLOGIC BUDGET

According to a 1965 WDNR bathymetric (depth) map, Friendship Lake has surface acres, and the volume of the lake is 680.6 acre-feet. The mean depth is 5.9 feet. The maximum depth is 15 feet.

Figure 34: Bathymetric Map of Friendship Lake

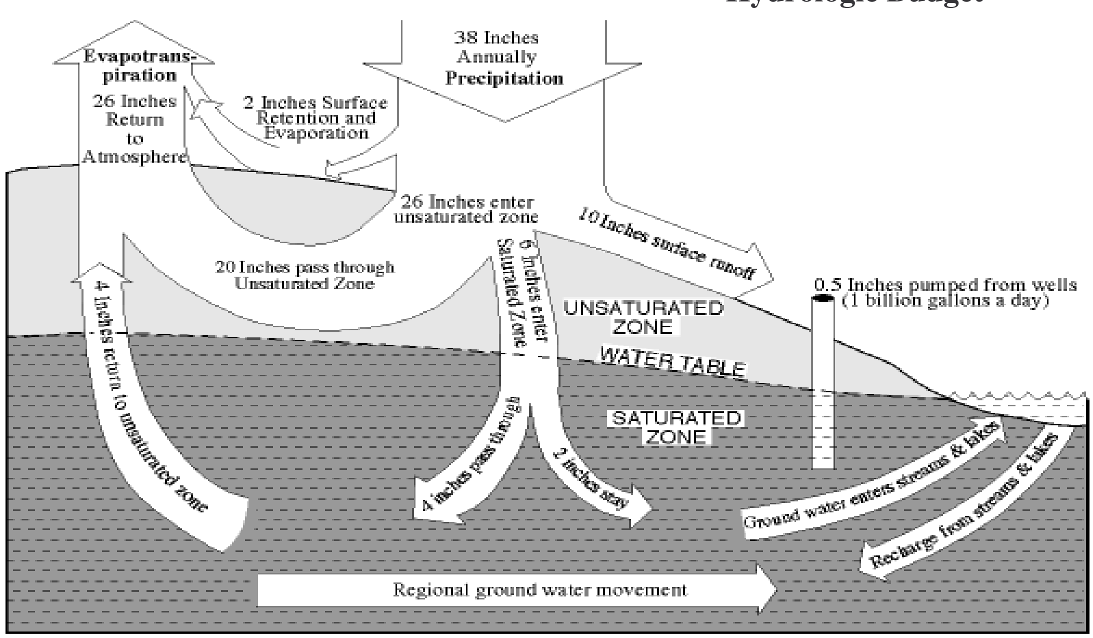


A "hydrologic budget" is an accounting of the inflow to, outflow from and storage in a hydrological unit (such as a lake). "Residence time" is the average length of time particular water stays within a lake before leaving it. This can range from several days to years, depending on the type of lake, amount of rainfall, and other factors. "Flushing rate" is the time it takes a lake's volume to be replaced. "Annual runoff volume", as used in WiLMS, is the total water yield from the drainage area reaching the lake. The "drainage area" is the amount of area (in acres) contributing surface water runoff and nutrients to the lake. The "areal water load" is the total annual flow volume reaching the lake divided by the surface area of the lake. "Hydraulic loading" is the total annual volume of all water sources (including precipitation, non-point sources & point sources) loading into the lake.

Using the data gathered from historical testing and that done by the Adams County LWCD from 2004-2006, the WiLMS model calculated the tributary drainage area for Friendship Lake as 23193.1 acres. The average unit runoff for Adams County in the Friendship Lake area is 9.4 inches. WiLMS determined the expected annual runoff volume as 18167.9 acre-feet/year. Anticipated annual hydraulic loading is 18192.8 acre-feet/year. Areal water load is 158.2 feet/year.

In an impoundment lake like Friendship Lake, a significant portion of the water and its nutrient load running through it from the impounded creek tend to flush through the lake and continue downstream—in Friendship Lake's case, modeling estimates a water residence of 0.01/year. The calculated lake flushing rate is 26.81 1/year. Water and its load flow through Friendship Lake fairly quickly.

Figure 35: Example of Hydrologic Budget



TROPHIC STATE

The trophic state of a lake is one measure of water quality, basically defining the lake's biological production status (see Figure 36). **Eutrophic lakes** are very productive, with high nutrient levels, frequent algal blooms and/or abundant aquatic plant growth. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small populations of fish. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; often with a more varied fishery than either the eutrophic or oligotrophic lakes. In comparing water quality testing results with the prediction from the computer modeling of this modeling with the actual figures outlined above, the actual Trophic State of Friendship Lake is what was predicted from the modeling. Modeling results predicted that the overall TSI for Friendship Lake would be **48**. This score places Friendship Lake's overall TSI at above average for impoundment lakes in Adams County (52.83).

Figure 36: Trophic Status Table

Friendship Lake = 48

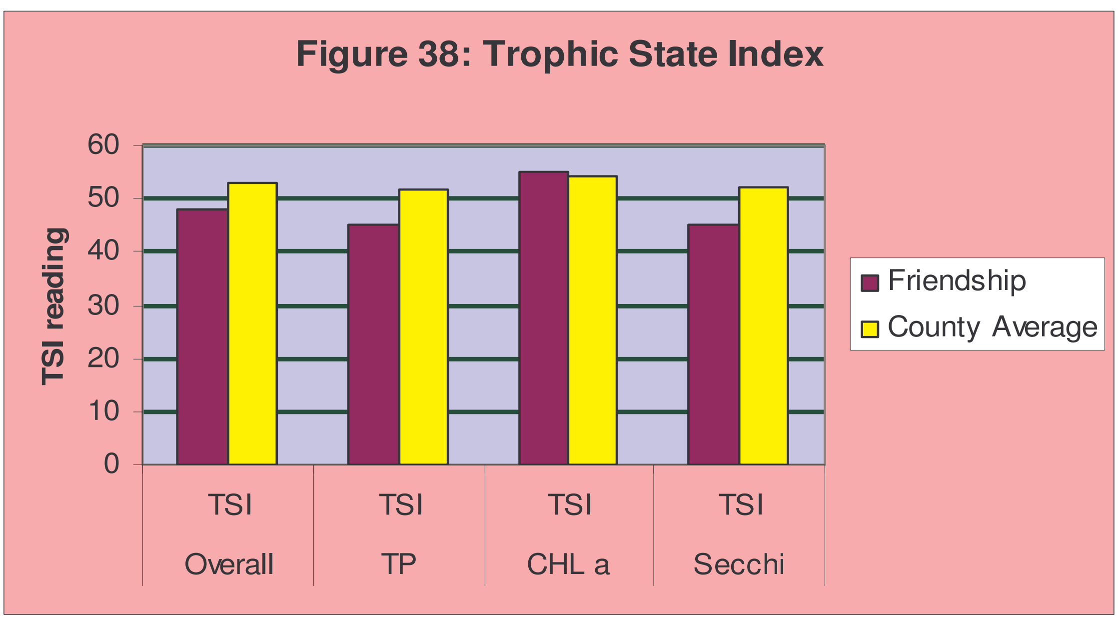
Score	TSI Level Description
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

Phosphorus concentration, chlorophyll-a concentration and water clarity data are collected and combined to determine a trophic state. As discussed earlier, the average summer epilimnetic total phosphorus for Friendship Lake was 36 micrograms/liter. The average summer chlorophyll-a concentration was 11.5 micrograms/liter. Growing season water clarity averaged a depth of 6.52 feet. Figure 37 shows where each of these measurements from Friendship Lake fall in trophic level.

Figure 37: Friendship Lake Trophic Status Overview

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	10 to 30	5 to 10	**6 to 8**
	Fair	**30 to 50**	**10 to 15**	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Friendship Lake		**36**	**11.5**	**6.52**

These figures show that Friendship Lake has fair to good levels overall for the three parameters often used to described water quality: Secchi disk depths; average TP for the growing season; and chlorophyll a levels. It is normal for all of these values to fluctuate during a growing season. However, they can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Friendship Lake is below the county impoundments average for overall TSI levels—which is positive, since with TSI levels, the lower the better.



IN-LAKE HABITAT

Aquatic Plants

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in improving water quality, providing valuable habitat resources for fish and wildlife, resisting invasions of non-native species and checking excessive growth of the most tolerant species.

An aquatic plant survey was done on Friendship Lake in the summer of 2006 by staff from the Adams County LWCD. Its trophic state should support moderate to dense plant growth and occasional algal blooms. Instead, filamentous algae were abundant in Friendship Lake, present at 100% of the samples sites and found even in the over 5 feet depth zone.

Despite the sometime limiting effect of sand sediments on aquatic plant growth, 88.9% of the lake bottom is vegetated, suggesting that even the sand sediments in Friendship Lake hold sufficient nutrients to maintain aquatic plant growth. Due to the shallow depth, sunlight can encourage plant growth at all depths in the lake.

The 0 to 1.5 feet depth zone had the highest frequency of growth. The quality of the aquatic plant community in Friendship Lake is below average for Wisconsin lakes and for lakes in the North Central Hardwood region, as measured by the Coefficient of Conservatims, but above average for the Floristic Quality Index. Structurally, it does contain emergent plants, rooted plants, floating plants and one rooted plant with floating leaves. However, the community is characterized by plants that tolerate a high amount of disturbance and abundant filamentous algae.

Vallisnera americana (Water Celery) was the most frequently-occurring plant in Friendship Lake in 2006, followed by *Wolffia columbiana* (Common Watermeal). No other species reached a frequency of 50% or greater, although *Ceratophyllum demersum* (Coontail) and *Lemna minor* (Small Duckweed) were not far below 50% frequency.

Vallisneria americana was also the densest plant in Friendship Lake and exhibited more than average density of growth. It was the only plant found in 2006 to show that density of growth in the lake overall. Based on dominance value, *Vallisneria americana* was the dominant aquatic plant species in Friendship Lake. Sub-dominant were *Wolffia columbiana, Ceratophyllum demersum* and *Lemna minor*. *Myriophyllum spicatu*m (Eurasian watermilfoil, an aggressive invasive), *Potamogeton crispus* (Curly-Leaf Pondweed, another invasive) and *Phalaris arundinacea* (Reed Canarygrass, a third invasive plant), the exotics found Friendship Lake, were not present in high frequency, high density or high dominance. It is possible that *Potamogeton crispus* is under-represented, since this survey was performed in August, somewhat later than its peak season

Figure 39: Friendship Lake Aquatic Plant Species 2006

Scientific Name	Common Name	Type
Alnus incana	Tag Alder	Emergent
Ascelpias incarnata	Swamp Milkweed	Emergent
Calamagrostis canadensis	Blue-Joint Grass	Emergent
Ceratophyllum demersum	Coontail	Submergent
Circuita bulbifera	Water Hemlock	Emergent
Cornus amomum	Silky Dogwood	Emergent
Elodea canadensis	Waterweed	Submergent
Impatiens capensis	Jewelweed	Emergent
Iris versicolor	Blue-Flag Iris	Emergent
Leersia oryzoides	Rice-Cut Grass	Emergent
Lemna minor	Lesser Duckweed	Free-Floating
Myriophyllum sibiricum	Northern Milfoil	Submergent
Myriophyllum spicatum	Eurasian Watermilfoil	Submergent
Najas flexilis	Bushy Pondweed	Submergent
Nymphaea odorata	White Water Lily	Floating-Leaf
Phalaris arundinacea	Reed Canarygrass	Emergent
Potamogeton amplifolius	Large-Leaf Pondweed	Submergent
Potamogeton crispus	Curly-Leaf Pondweed	Submergent
Potamogeton natans	Floating-Leaf Pondweed	Submergent
Potamogeton pectinatus	Sago Pondweed	Submergent
Potamogeton pusillus	Small Pondweed	Submergent
Potamogeton zosteriformis	Flat-Stemmed Pondweed	Submergent
Ribes americanum	Wild Currant	Emergent
Rumex spp	Water Dock	Emergent
Salix spp	Willow spp	Emergent
Scirpus spp	Bulrush	Emergent
Scirpus cyperinus	Woolgrass	Emergent
Scirpus microcarpus	Panicled Bulrush	Emergent
Scirpus validus	Soft-Stem Bulrush	Emergent
Solanum dulcamara	Nightshade	Emergent
Solidago spp	Goldenrod	Emergent
Spirodela polyrhiza	Greater Duckweed	Free-Floating
Typha latifolia	Narrow-Leaf Cattail	Emergent
Vallisneria americana	Water Celeery	Submergent
Wolffia columbiana	Watermeal	Free-Floating
Zosterella dubia	Water Stargrass	Submergent

The Simpson's Diversity Index for Friendship Lake was .92, suggesting good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The Aquatic Macrophyte Community Index (AMCI) for Friendship Lake is 53. This is average for Central Wisconsin Hardwood Lakes and Impoundments. The aquatic plant community in Friendship Lake is in the category of those most tolerant of disturbance, likely from a high amount of disturbance compared to other Wisconsin lakes.

The presence of the three invasives is a significant factor. Currently, their density and relative frequency doesn't establish them as dominant among Friendship Lake's aquatic plant community, but their tenacity and ability to spread to large areas fairly quickly make them a danger to the diversity of Friendship Lake's aquatic plant community. The Friendship Lake District has been spot-treating chemically sporadically since 1960. In 1993, it started using mechanical harvesting as its main method of managing the aquatic plants. That has continued through 2007.

Previously, a value was assigned to all plants known in Wisconsin to categorize their probability of occurring in an undisturbed habitat. This value is called the plant's Coefficient of Conservatism. A score of 0 indicates a native or alien opportunistic invasive plant. Plants with a value of 1 to 3 are widespread native plants. Values of 4 to 6 describe native plants found most commonly in early successional ecosystem. Plants scoring 6 to 8 are native plants found in stable climax conditions. Finally, plants with a value of 9 or 10 are native plants found in areas of high quality and are often endangered or threatened. In other words, the lower the numerical value a plant has, the more likely it is to be found in disturbed areas.

The Average Coefficient of Conservation for Friendship Lake was 4.15. This puts it in the lowest quartile for Wisconsin Lakes (average 6.0) and for lakes in the North Central Hardwood Region (average 5.6). The aquatic plant community in Friendship Lake is in the category of those most tolerant of disturbance, probably due to selection by a series of past disturbances.

Figure 40: Aquatic Vegetation Types

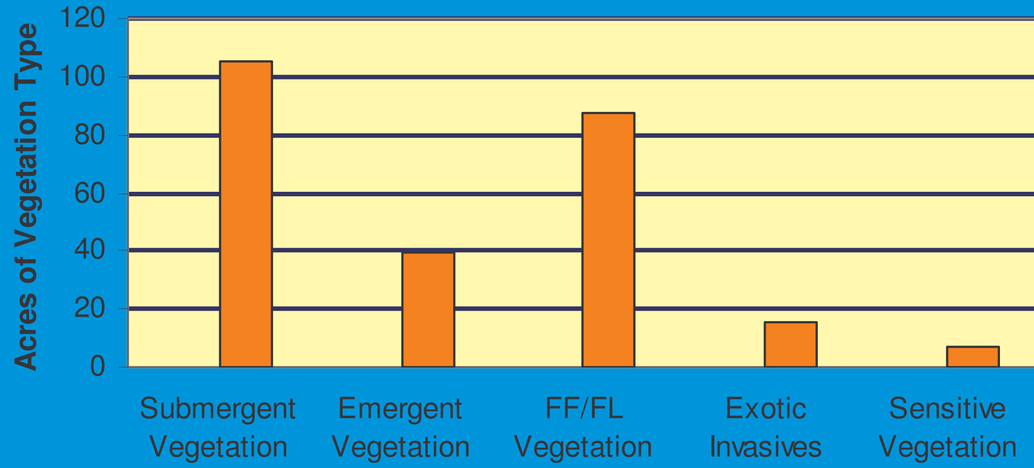


Figure 41a: Distribution of Emergent Plants in Friendship Lake 2006

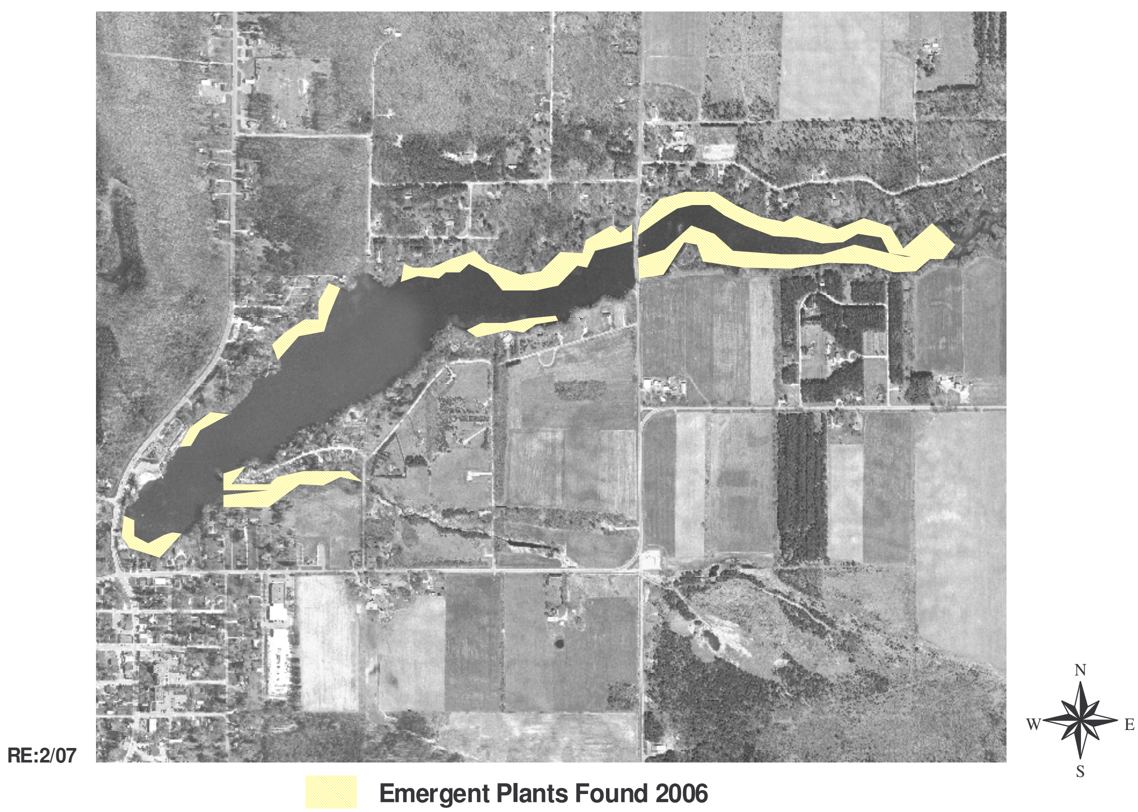


Figure 41b: Distribution of Free-Floating & Floating-Leaf Plants in Friendship Lake in 2006

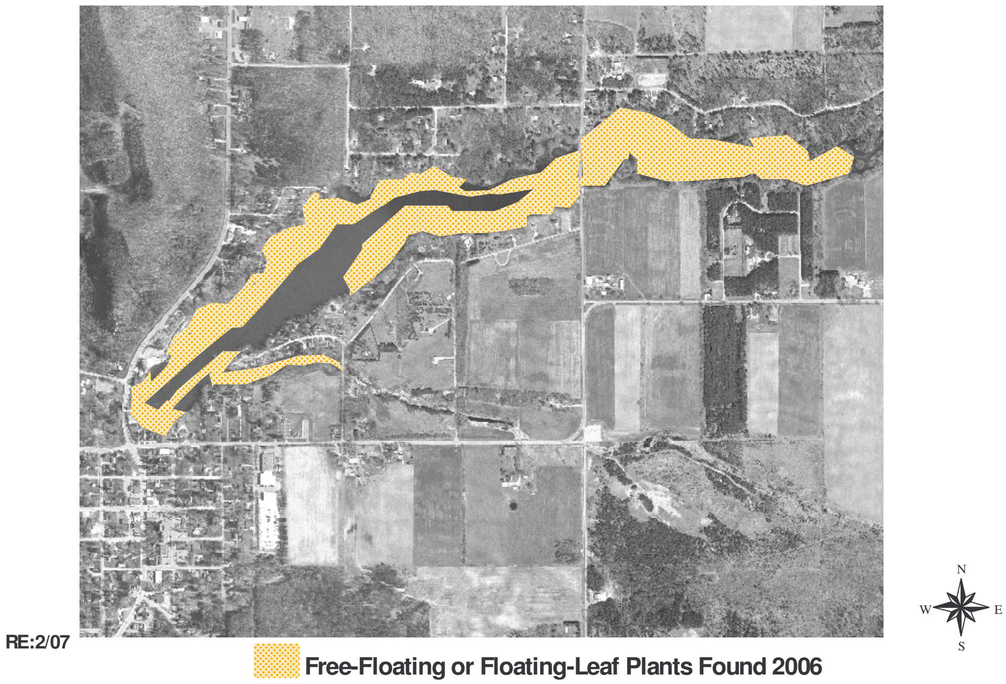
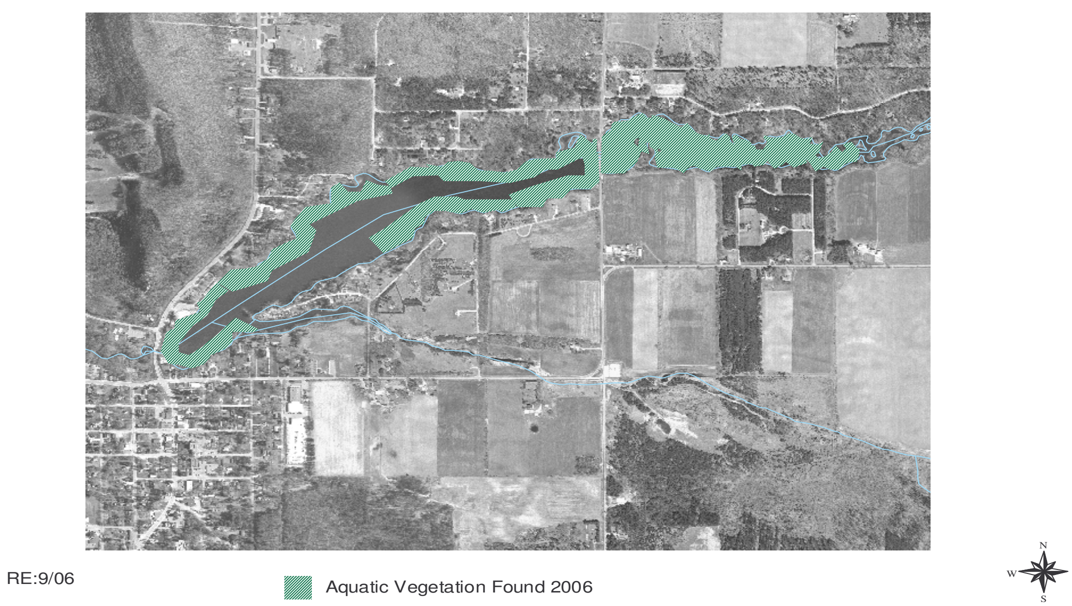


Figure 41c: Submergent Aquatic Plants in Friendship Lake 2006



Some of the sample transects had an entirely native shore, although more had sites that had been disturbed by humans. Data from the disturbed shores was compared to data from the natural shores, revealing that the disturbed shores had higher scores for the FQI and species number, but natural shores had a higher Coefficient of Conservatism, higher Simpson's Diversity Index, and higher Aquatic Macrophyte Community Index. The high amount of disturbance in the lake overall probably explains this variety of differentiation between natural and disturbed shores.

Figure 42: Comparison of Natural & Disturbed Shores

	Natural	Disturbed
Number of species	25	30
FQI	22.4	23.92
Average Coef. Of Cons	4.48	4.37
Simpson's Index	0.93	0.89
AMCI	51	50
Filamentous algae	100%	100%

The first aquatic plant survey, a qualitative one, was by DNR staff in 1956. This qualitative survey showed that *Ceratophyllum demersum* (coontail) and *Brasenia scherberi* (watershield) were abundant; white and yellow water lilies, as well as *Potamogeton amplifolius* (large-leaf pondweed), *Vallisneria americana* (water celery), and *Potamogeton filimormia* (thread-leaf pondweed) were common. *Lemna minor, Elodea canadensis* and watermilfoil were present, but scarce.

Another qualitative survey was conducted in 1980. Abundant were coontail, cattail, milfoil, water celery, sedges, burreeds, and filamentous algae. Common were *Elodea canadensis* (waterweed), *Potamogeton natans* (floating-leaf pondweed), *Potamogeton zosteriformis* (flat-stem pondweed), *Najas flexilis* (bushy pondweed), and *Iris versicolor* (blue-flat iris). Also present were *Asclepias incarnata* (swamp milkweed), burreed, *Zosterella dubia (*water stargrass), duckweed, water lily and large-leaf pondweed.

The first quantitative vegetation survey of Friendship Lake was completed by WDNR staff and members of the Friendship Lake District in July 2003. At that time, 15 species of aquatic vegetation were found; none were emergent. The highest frequency and density of aquatic plants was in the 1.5 foot-5 foot depth zone (Zone 2). The exotic invasive, *Myriophyllum spicatum* (Eurasian watermilfoil) was found, but did not have a high frequency or density.

With this kind of aquatic plant history, comparisons were made for the four aquatic plant surveys to identify any changes and/or trends. Figure 43 shows some of the most basic comparisons.

Figure 43: Comparison Table for Aquatic Plant Surveys

	2006	2002	1992	1979
Number of species	33	15	13	17
FQI	23.85	18.85	14.98	20.86
Average Coef. Of Cons	4.87	4.15	4.15	5.06
Simpson's Index	0.92	0.86	NA	NA
AMCI	53	41	NA	NA
Species Richness	4.68	3.08	NA	NA

The number of species has increased from 17 in 1979 to 33 in 2006. The Floristic Quality Index has also gotten better, as has the Simpson's Diversity Index, AMCI and Species Richness. However, the Coefficient of Conservatism has gone down from 5.06 to 4.87. This suggests that the Friendship Lake aquatic plant community may be increasing its species number (thus affecting the richness), but most of the new species are those tolerant of disturbance.

Further, when calculating the coefficient of similarity between the 2002 and 2006 surveys, they score as statistically dissimilar. Based on frequency of occurrence, the aquatic plant communities of the two years are only 62% similar. Based on relative frequency, they are 41% similar. Similarity percentages of 75% are considered statistically similar; obviously, Friendship Lake percentages are far from that.

It is worth noting that the report on the 2002 aquatic plant surveys mentioned the absence of emergent plants in Friendship Lake. The 2006 survey shows that emergent plants are "coming back", i.e., are re-establishing in Friendship Lake.

However, one point of concern is the reduced frequency of occurrence of *Nymphaea odorota* by about one-half. The water-lilies are needed as habitat, feeding and cover areas for many species. An additional issue is the new and substantial presence of free-floating plants like *Lemna minor, Spirodela polyrhiza* and *Wolffia columbiana.* The high frequency and density of such species suggests a significant nutrient increase in the waters of Friendship Lake.

Figure 44: Further Comparison Table of Aquatic Plant Community

Friendship	2002	2006	Change	%Change
Number of Species	15	**33**	18	120.0%
Maximum Rooting Depth	10.0	**12.5**	3	25.0%
% of Littoral Zone Unvegetated	**16.70%**	11.10%	-0.056	-33.5%
%Sites/Emergents	0.00%	23.21%	0.2	23.2%
%Sites/Free-floating	10.00%	76.79%	0.7	667.9%
%Sites/Submergents	100.00%	96.43%	0.0	-3.6%
%Sites/Floating-leaf	10.00%	5.36%	0.0	-46.4%
Simpson's Diversity Index	0.86	**0.92**	0.06	7.0%
Species Richness	3.08	**4.68**	1.60	51.9%
Floristic Quality	18.85	**23.85**	5.00	26.5%
Average Coefficient of Conservatism	**4.87**	4.15	-0.72	-14.8%
AMCI Index	41	**53**	16.00	39.0%

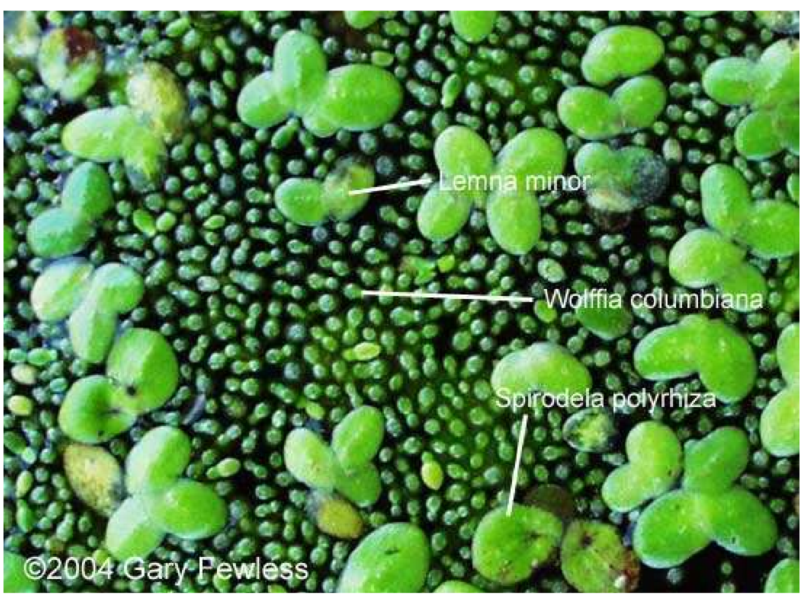
Vallisneria americana
(Wild Celery)

Figure 45: Most Common Native Aquatic Species in Friendship Lake

Ceratophyllum demersum
(Coontail)

Lemna minor
(Small Duckweed)

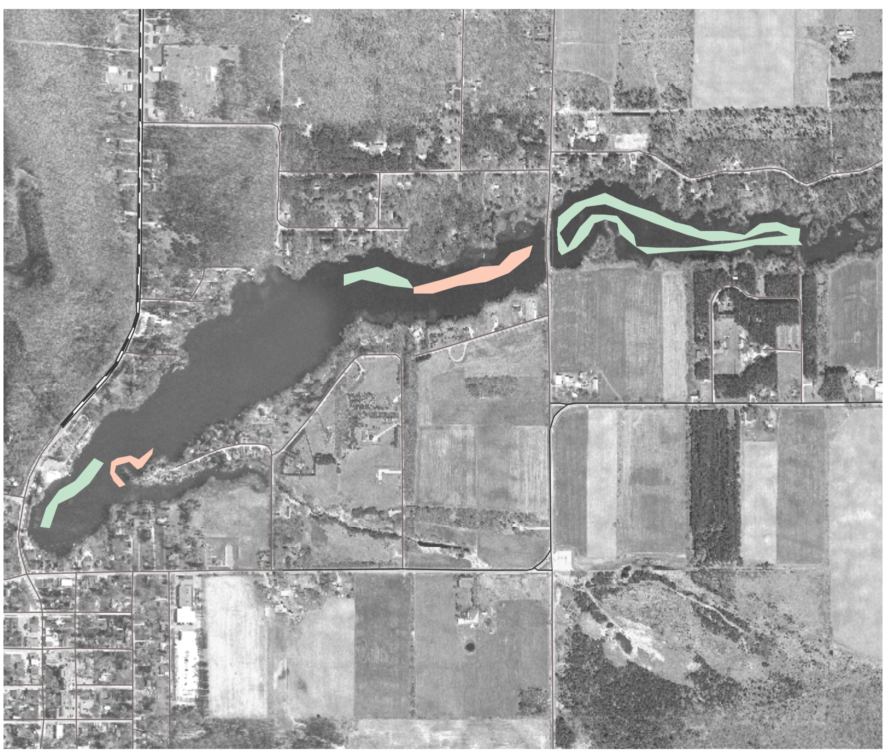
Wolffia columbiana
(Common Watermeal)



Aquatic Invasives

Friendship Lake has three known invasive aquatic species: Curly-Leaf Pondweed (submergent); Eurasian Watermilfoil (submergent) and Reed Canarygrass (emergent). The lake gets a significant amount of transient boat traffic due to its location (right off a main highway) and easy-to-use free public boat ramp. The Friendship Lake District has a lake management plan that includes management of aquatic invasives. In the past, two citizens regularly monitored the lake for twelve years. However, they are now in the process of moving from the lake. In 2008, a citizen monitoring group will be trained to monitor the aquatic invasives and participate in the Clean Boats, Clean Waters boater education program.

Figure 46a: Distribution of Exotic Aquatic Plants in 2006



RE:9/06 Curly-Leaf Pondweed Found Eurasian Watermilfoil Found

Figure 46b: The Invasive Aquatic Plants in Friendship Lake

Myriophyllum spicatum
(Eurasian Watermilfoil)

Potamogeton crispus
(Curly-Leaf Pondweed)

Phalaris arundinacea
(Reed Canarygrass)

Critical Habitat

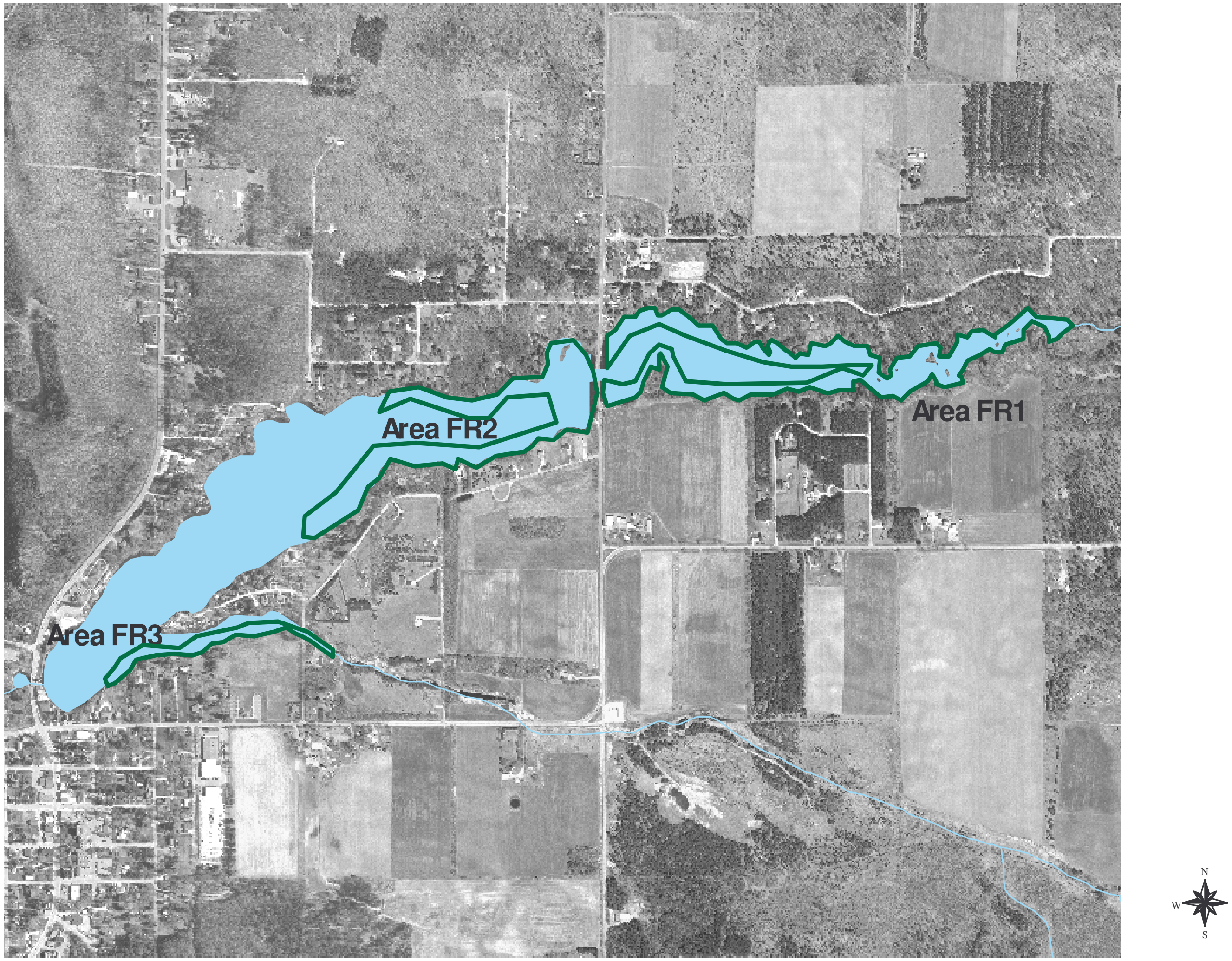
Designation of critical habitat areas within lakes provides a holistic approach for assessing the ecosystem and for protecting those areas in and near a lake that are important for preserving the qualities of the lake. Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes.

Protection of critical habitat areas must include protecting the shore area plant community, often by buffers of native vegetation that absorb or filter nutrient & stormwater runoff, prevent shore erosion, maintain water temperature and provide important native habitat. Buffers can serve not only as habitats themselves, but may also provide corridors for species moving along the shore.

Besides protecting the landward shore areas, preserving the littoral (shallow) zone and its plant communities not only provides essential habitat for fish, wildlife, and the invertebrates that feed on them, but also provides further erosion protection and water quality protection.

Field work for a critical habitat area study was performed on September 19, 2006, on Friendship Lake, Adams County. The study team included: Scot Ironside, DNR Fish Biologist; Deborah Konkel, DNR Aquatic Plant Specialist; and Reesa Evans, Adams County Land & Water Conservation Department. Areas were identified visually, with GPS readings and digital photos providing additional information. Input was also gained from Terry Kafka, DNR Water Regulation; Jim Keir, DNR Wildlife Biologists; and Buzz Sorge, DNR Lake Specialist. Three areas of Friendship Lake were designated as Critical Habitat Areas.

Critical Habitat Areas--Friendship Lake



RE:8/06

Figure 47: Critical Habitat Areas on Friendship Lake

Critical Habitat Area FR1

This area extends along over 6000 feet of the shoreline on both sides of the eastern end of Friendship Lake. This area of Friendship Lake is very shallow and is largely undeveloped. 46.7% of the shore is wooded; 21.7% has shrubs; the remaining shore (31.6%) is native herbaceous cover. Much of this area is a marsh. Large woody cover is common for habitat. With little human disturbance along this shoreline, the area has natural scenic beauty.

Figure 48: Southeast End of FR1

Filamentous algae were found at 100% of the sites in this critical habitat area.

This area of large woody cover, emergent aquatic vegetation, submergent and floating vegetation provides spawning and nursery areas for many types of fish: northern pike; largemouth bass; bluegill; pumpkinseed; yellow perch; crappie; bullhead; and other panfish. All of these fish also feed and take cover in these areas. Rusty crayfish, an exotic invasive species, is known to occur in Friendship Lake, although none were seen during the field survey for this report.

Beaver, muskrat, mink and otter are known to use this habitat for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl and songbirds. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well. Since human disturbance is especially light in FR1, it provides excellent habitat for many types of wildlife.

Maximum rooting depth of aquatic vegetation in FR1 was 5 feet. Nine emergent species, including the invasive *Phalaris arundicaea*, were found at this site. Three species of free-floating plants and one species of floating-leaf rooted plant were found here. Ten submergent aquatic plant species, including the invasive *Myriophyllum* spicatum, were found in this area. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. Floating-leaf vegetation provides cover and dampens waves, protecting the shore. A diverse submergent community provides many benefits.

Critical Habitat Area FR2

This area extends along approximately 5000 feet of the north and south shoreline in the middle of the lake's length. 35% of the shore is wooded; 14% has shrubs; 38% is native herbaceous cover. The remaining shoreline is bare/eroded sand and some hard structures. Large woody cover is common for habitat. With minimal human disturbance along this shoreline, some of the area is has natural scenic beauty.

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Figure 49: Southeast Area of FR2

This area of commonly-occurring large woody cover, emergent aquatic vegetation, submergent and floating vegetation provides spawning and nursery areas for many types of fish: northern pike; largemouth bass; bluegill; pumpkinseed; yellow perch; crappie; bullhead; and other panfish. All of these fish also feed and take cover in these areas. Rusty crayfish are known to occur in Friendship Lake, although none were seen during the field survey. Some shore development was present in FR2. Various types of wildlife were seen and heard during the field survey. Upland wildlife are known to use this area as well. Downed logs serving as habitat were also seen

Maximum rooting depth in FR2 was 18 feet. No threatened or endangered species were found in this area. Two exotic invasives, *Myriophyllum spicatum* (Eurasian watermilfoil) and *Phalaris arundinacea* (Reed Canarygrass) were found in this area. Filamentous algae occurred at all sites, especially near the shores. Found at this site were seven species of emergent aquatic plants, three species of free-floating aquatic plants, one species of floating-leaf rooted plant, and eleven submergent aquatic species.

CRITICALHABITAT AREA FR3

This area extends along approximately 2100 feet of the southwest shoreline. 47.5% of the shore is wooded; 5% has shrubs; 15% is native herbaceous cover—the remaining shore is bare sand and hard structure. This critical habitat area includes some of most developed area of Friendship Lake, although the southeast side of this area is currently undeveloped.   Large woody cover is present, but not as much as in the other two critical habitat areas. Scenic beauty in part of the area is lessened on the north and southwest sides due to the human development, but the southeast area of this site is still pretty.   This area does still provide spawning and nursery areas for many types of fish, as well as several types of wildlife.

Maximum rooting depth in FR3 was 13 feet. No threatened or endangered species were found in this area. All of the area had filamentous algae, especially near the shores. Only one emergent species was found here. Two species of floating-leaf rooted plants were present. Also present were three species of free-floating plants. Six submergent plant species were found. This is a less diverse submergent community than the other critical habitat sites in Friendship Lake.

Figure 50: Southern Curve in Area FR3

Critical Habitat Recommendations

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove any fallen trees along the shoreline.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain any snag/cavity trees for nesting.
(6) Install nest boxes.
(7) Maintain or increase wildlife corridor.
(8) Maintain no-wake lake designation.
(9) Protect emergent vegetation.
(10) Seasonal control of Eurasian Watermilfoil and other invasives with methods selective for control of exotics.
(11) Continue mechanical harvesting, thus removing some of the phosphorus from the lake.
(12) Develop & implement control plan for invasive Rusty Crayfish.
(13) Minimize aquatic plant and shore plant removal to maximum 30' wide viewing/access corridor and navigation purposes. Leave as much vegetation as possible to protect water quality and habitat.

(14) Use best management practices.
(15) No use of lawn products.
(16) No bank grading or grading of adjacent land.
(17) No pier placement, boat landings, development or other shoreline disturbance in the shore area of the wetland corridor.
(18) No pier construction or other activity except by permit using a case-by-case evaluation and only using light-penetrating materials.
(19) No installation of pea gravel or sand blankets.
(20) No bank restoration unless the erosion index scores moderate or high.
(21) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(22) Placement of swimming rafts or other recreational floating devices only by permit.
(23) Maintain aquatic vegetation buffer in undisturbed condition for wildlife habitat, fish use and water quality protection.
(24) Post exotic species information at public boat landing.
(25) Investigate making the far east end of the lake a conservancy or purchasing an easement to maintain its mostly undisturbed state.

Figure 51: Shore with Snag on Friendship Lake

FISHERY/WILDLIFE/ENDANGERED RESOURCES

WDNR fish stocking records for Friendship Lake go back to 1933, when walleye and black bass were stocked. Through the next 25 years, stocking occurred frequently, generally concentrating on largemouth & smallmouth bass, bluegills, perch, walleye and northern pike. There was a fish removal in 1984 that revealed that there were about four times more bluegills than all the other fish found put together. The most recent inventory, done in 2002, found that largemouth bass and bluegills were abundant, yellow perch and white sucker were scarce, and pumpkinseed and black crappie were present. Carp have also been found in the lake in the past.

Muskrat and mink are also known to use Friendship Lake shores for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known, using the lake shores for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Upland wildlife feed and nest here as well.

Many endangered resources are found in the Friendship Lake watersheds. Natural communities known to be present include alder thicket, central poor fen, floodplain forest, northern dry forest, northern sedge meadow, oak barrens, pine barrens, sand barrens, shrub-carr and stream (fast, hard, cold). Endangered birds found are Greater Prairie Chicken and Red-Shouldered Hawk. Invertebrates of concern include Karner Blue Butterfly, Persius Dusky Wing Butterfly, and Sand Snaketail dragonfly. Several endangered plants—Crossleaf Milkwort, Slim-Stem Small Reedgrass, Whip Nutrush—are also present.

Lycaeides Melissa samuelis
(Karner Blue Butterfly)

Scleria triglomerata
(Whip Nutrush)

Erynnis persius
(Persius Dusky Wing)

Polygala cruciata
(Crossleaved Milkwort)

Figure 52: Photos of some of the species of concern in Friendship Lake Watersheds

*information courtesy of Wisconsin Department of Natural Resources

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